COMPARISON OF INTRUSION OF MAXILLARY INCISORS USING THREE-PIECE INTRUSION ARCH AND SKELETAL ANCHORAGE-A FINITE ELEMENT STUDY

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CHENNAI

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"COMPARISON OF INTRUSION OF MAXILLARY INCISORS USING THREE PIECE INTRUSION ARCH AND SKELETAL ANCHORAGE- A FINITE ELEMENT STUDY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr.Rekha Bharadwaj.M.D.S., D.I.B.O.,** Reader, Department of Orthodontics and Dentofacial Orthopedics, Ragas Dental College and Hospital, Chennai.

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CERTIFICATE

This is to certify that this dissertation titled **"COMPARISON OF INTRUSION OF MAXILLARY INCISORS USING THREE PIECE INTRUSION ARCH AND SKELETAL ANCHORAGE- A FINITE ELEMENT STUDY"** is a bonafide record work done by **Dr. Kowtham Raj.M** under my guidance during his post graduate study period 2016-2019.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY,** in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY in BRANCH V** - Orthodontics and Dentofacial Orthopedics. It has not been submitted (partially or fully) for the award of any other degree or diploma.

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ABSTRACT

Aim:

The aim of the study was to compare the resultant stress and displacement of the dentition of the four maxillary incisors with three-piece intrusion arch and the mini-implant assisted intrusion using finite element method

Material and methods:

For this investigation, the geometric model of the maxilla was constructed using a computed tomography scan. 0.022 slot Roth brackets and molar tubes were modelled for maxillary teeth in Group A (three piece intrusion arch) and Group B (mini implant).The wire components for the three-piece intrusion arch was modelled initially as line diagram and then converted in to three-dimensional models for Group A.

In Group B two mini-implants of 1.3 x 7 mm was simulated and modelled. The material characteristic which include the Young's modulus and Poisson's ration were assigned after defining the boundary conditions and force systems were applied. The analysis was carried out using Abacus version 6.1 was used. The Von mises stress and displacement of four maxillary incisors were analysed and calculated.

Results:

(1) The maximum principal compressive stress was negligible in mini implant groups compared to the three piece intrusion arch.

(2) Displacement of four incisors were significantly different in both the groups in sagittal and vertical plane demonstrating true incisor intrusion and minimal flaring of the anterior incisor with implant assisted intrusion.

Conclusion:

Mini implants have been found to be beneficial and biomechanically efficient in intruding four incsiors with minimal flaring of the anterior teeth.

Key words: Maxillary incisors intrusion, three-piece intrusion arch, mini-implants, FEM.

CONTENTS

Introduction

INTRODUCTION

Deep bite is one of the most common malocclusions seen in both children and in adults either independently or in concurrent with other malocclusions.[4]

Graber has stated that “deep bite” is a condition of excessive overbite, where the vertical measurement between the maxillary and mandibular incisal margin is excessive when the mandible is brought into habitual or centric occlusion. Deep bite develops due to the dentoalveolar extrusion of maxillary incisors from its normal site and usually seen in Class I and Class II malocclusions. It can cause deleterious effects to the masticatory apparatus and the dental units, if left untreated.

Anterior deep bite is caused by the overeruption of the maxillary incisors and can be quantified using lateral cephalometric radiographs. According to Lewis, if the lower lip covers more than 4 mm of the maxillary central incisors on a patient’s lateral cephalometric radiographs, it is contemplated to be maxillary incisor overeruption.[42]

Correction of deep overbite and its maintenance poses a great challenge to the orthodontist and a wide variety of techniques have been developed to accomplish it. Each technique of deep overbite correction has its own advantages and limitations Based on the diagnosis and treatment objectives, a deep overbite can be corrected by intruding the incisors, extruding the buccal segments, or combination of both.[10]

Extrusion of posterior teeth descents the mandible downward and backward, while the condyle assumes a new position in the temporomandibular joint articulation. If equilibrium is established between function, muscles, and the temporomandibular joint after orthodontic treatment by remodelling and readaptation, then the correction of deep overbite achieved by extruding the posterior teeth remains stable. In adults, however, the masticatory muscles and the altered occlusion might move the extruded posterior teeth back to the original positions until balance between the soft and hard tissues is obtained. However, if imbalance persist there is a greater tendency for relapse to occur. Therefore, in adults, the skeletal discrepancy can be compensated either by dentoalveolar orthodontics with fixed appliances or orthognathic surgery.[67]

Maxillary incisor intrusion should be the desired treatment option for non-growing patients with anterior deepbite which is caused by overeruption of the maxillary incisors. Intrusion arches are commonly used to treat deep overbite. However, undesirable side effects such as extrusion of the posterior teeth or flaring of the anterior teeth limits the treatment efficiency. Moreover, vertical forces can be heavier than the desired forces and it may cause changes in the balance between intrusion of the incisors and extrusion of the molars. Anchorage control, especially in the vertical dimension, is most significant if an effective bite opening is to be created by genuine intrusion of the anterior teeth. Although extra oral appliances provide sufficient anchorage, they require excessive patient cooperation. Maximizing desired tooth movements and minimizing unwanted side effects are the important goals of orthodontic treatment.

Conventional methods of incisor intrusion usually include 2 ×4 appliances such as utility arches, 3-piece intrusion arches and reverse curved arches. Labial tipping of the anterior teeth is a common outcome of these arches and it gives the impression of deep bite correction from the change in the vertical incisal edge positions.[56]

In the 1997 Bhavna Shroff developed the three-piece intrusion arch, in which the arch wire consisted of an anterior and posterior intrusive component for correcting deep overbite in patients with flared incisors for both extraction and non-extraction cases. The study claimed that the three-piece intrusion arch assured a predictable, reproducible and statistically determinate force system with minimal chair side adjustments.[63]

Basic mechanism of a three-piece intrusion arch consist of a) posterior anchorage unit, b) anterior segment c) intrusive arch spring.

The overview of skeletal anchorage as a source of stationary anchorage to orthodontic forces has made the most complex tooth movements simpler. Because of their smaller dimensions, mini implants offer the advantages of immediate loading, multiple placement sites, relatively simple placement and removal, placement in interdental areas where traditional implants cannot be placed, and cost effective. It has been shown that mini implants can be loaded up to 500 g of forces and yet it can stay intact until the end of the treatment.

Furthermore, intrusion with mini-implants increases the treatment efficiency with minimal need on patient cooperation. Although there are few literature reports on the efficiency of the implant supported intrusion, till date there has been no study done to compare the efficiency and outcome of intrusion using three-piece intrusion arch and mini implant assisted intrusion.[55]

Apical root resorption is a common antagonistic effect during orthodontic treatment. In 1927, Ketcham was the first to generate interest in such consequences of orthodontic treatment with substantial amount of research. It is still debated if a particular method of treatment used by the orthodontist influences the amount of root resorption. Of particular interest, apical root resorption is more perceptible on radiographs when compared with buccal or lingual root resorption. The apical area receives the greatest concentration of force since it is the surface that faces the direction of physiologic movement during intrusion.

With the advent of three dimensional (3D) numerical computer analysis such as finite element method (FEM), valuable information can be obtained by simulating various clinical conditions and with this method the stress distribution in the periodontium and displacement of the dentition with the different quantum and vectors of force systems can be quantified.[59]

The aim of the study was to compare the resultant stress and displacement of the dentition of the four maxillary incisors with three-piece intrusion arch and the mini-implant assisted intrusion using finite element method.

Review of Literature

REVIEW OF THE LITERATURE

Leonard .I .Linkow (1970)[40] defines the use of implant in orthodontics. The use of endosseous implants in orthodontics has been comparatively uncommon.. One of the fields in which implants promises to be exceedingly useful adjunct to conventional therapy is orthodontics. Nevertheless, the implant designs and techniques need to be improved and validated in future.

Mark.E.Simons (1973)[65] in his 10 year of post retention study about deep-bite cases he resolved that proclination of lower incisors in deep-bite correction led to relapse of the overbite. Therefore he concluded that overbite correction should not be done by proclination of incisors . Lack of vertical mandibular growth during correction of deep-bite resulted in relapse. Stability of overbite also varies on the increase in anterior and posterior dentoalveolar heights. Occlusal plane descents during correction and returned to same angulation later resulting in relapse.

Burstone C.R (1977)[17] described about the necessity and differences in treatment mechanics for intrusion as not all patients can be treated using the same modality. He proposed six principles must be considered in incisor or canine intrusion: (1) use of optimal magnitude and constant of force delivery force with low load-deflection springs; (2) use of a single point contact in the anterior region ; (3) point of force application with respect to the center of resistance of the teeth to be intruded; (4) selective intrusion based on anterior tooth geometry; (5) control over the reactive units by a posterior anchorage unit ; and (6) inhibition of eruption of the posterior teeth and avoidance of undesirable eruptive mechanics.

Burstone and Pryputniewicz (1980)[57] pronounced the non-invasive holographic technique for measurement of tooth displacements offers three-dimensional accuracy and precision in quantifying the outcomes of time and force magnitude on tooth movement. The results clearly displays the force applied at the crown produces the centre of rotation apical to the centre of resistance; the longer the root, the more apical the centre of rotation. Also, it was found that the centre of rotation was moving further apically with the collective force magnitude, for a constant M/F ratio and the same root geometry. Furthermore, the velocity curves show that the tooth was still moving at a time of 45 sec after the instant application of force, although much slower than at the immediate loading. The technique used in this study was significant improvement over the previous methods, since it was a non-invasive, more accurate, and three-dimensional.

Radney L.J (1981)[58] investigated retrospectively the soft-tissue profile response to total surgical maxillary intrusion performed to reduce vertical maxillary excess using lateral head films of ten adult patients taken preoperatively and at least 6 months postoperatively. He specified that soft-tissue profile changes associated with total surgical maxillary intrusion are anticipated. The nasolabial angle and the upper lip changed as per the direction and amount of maxillary intrusion. The lower border of the upper lip (Sto) moved superiorly with intrusion. The vertical reduction of the LS-to-St0 distance (vertical lip thinning) was influenced on the both intrusion and retraction of the anterior maxilla and posterior maxilla. The change in the lower lip (LS) after maxillary intrusion was unpredictable. The soft-tissue chin (ILS, PgS) responded to posterior maxillary intrusion by auto rotating on the same arc as the bony chin on a 1: 1 basis. The nasal tip (Pn) moved superiorly slightly with maxillary intrusion and protraction.

Creekmore et al (1983)[25] performed a study to determine if a metal implant could withstand a constant force over a long period of time of sufficient magnitude to depress an entire anterior maxillary dentition without becoming loose, infected, painful, or pathologic. The patient was a 25-year-old female with a Class I molar relationship and had a very deep overbite. Maxillary incisors were very long relative to the upper lip. Maxillary lateral incisors were peg-shaped. Orthodontic appliances were placed on the maxillary teeth, a surgical vitalium bone screw was inserted just below anterior nasal spine. Ten days after the placement of screw, a light elastic thread was tied from the head of the screw to the arch wire. The elastic thread was changed throughout treatment, so that a continuous force was maintained 24 hours a day till the screw was removed one year later. During this time, the author noticed that maxillary central incisors were elevated approximately 6mm and torqued lingually about 25 degrees. The bone screw did not move during treatment and was not mobile at the time when it was removed.

Rolf Berg (1983)[9] did a study with plaster models and lateral skull radiographs of 26 orthodontically treated deep overbite cases, which were analysed before and after treatment and 5–9 years out of retention. The mean age at the follow-up examination was approximately 22 years. The anticipated incisor relationship was achieved in the long term in 24 of the cases. The effect of several factors, stated in the literature to be important in the stability of treated deep overbite, was assessed. A considerable range of variation in the behaviour or influence of these factors was found. No marked difference was observed in the long term effects of treatment on the incisor occlusion in the 19 Class 2 Division 1 and the 7 Class 2 Division 2 cases in the sample.

Vanden Bulcke (1986)[70] studied twelve different systems of intrusion on macerated human skull, based on the principle of the "segmented arch". The number of teeth involved in the anterior unit and the location of the application points of intrusive force were considered to be variables. Initial displacements of the anterior teeth after loading were enumerated by means of the laser reflection technique and double exposure holographic recordings. An effort was made to define "this" intrusive system, achieving the most genuine intrusion without flaring of the teeth. When two central incisors were incorporated in the sectional wire, strong torque forces appeared, especially when the intrusive forces apprehended more distally. When four or six anterior teeth were pinned in the sectional wire, tooth movement seemed to be under better control. When the six front teeth were incorporated in the sectional wire, the centre of resistance was positioned more to the distal side of the canines. It seemed more difficult, however, to describe the centre of resistance of the four incisors; it was situated approximately distal to the lateral incisors. In some of the intrusive systems, the teeth underwent independent mesial or distal rotations. This was easily observed with the laser measuring techniques used.

Berte Melsen (1986)[47] did a study on three Macaca fascicularis monkeys to find out tissue reaction following application of extrusive and intrusive forces on teeth. By means of a segmented arch approach, the upper incisors and the four first premolars were subjected to a forced eruption for 8 weeks followed by 12 weeks of intrusion. On the right side of the mouth, the teeth were brushed with chlorhexidine three times per week. On the left side, no oral hygiene was performed. After intrusion of the teeth, a 1 to 14 day retention period with passive appliance, the animals were killed and histological assessment was performed. Based on histological studies she concluded that intrusion of teeth does not result in decrease of the marginal bone level provided the gingival inflammation is kept to a minimum.

Berte Melsen (1989)[45] did a study in thirty patients who had marginal bone loss and deep overbite and were treated by intrusion of incisors. Three different methods for intrusion were applied: (1) J hooks and extra oral high-pull headgear, (2) utility arches, (3) intrusion arch with loop in a 0.17 x

0.25~inch wire, and (4)base arch as described by burstone. The intrusion was assessed from the displacement of the apex, incision, and the centre of resistance of the most prominent or elongated central incisor. Change in the marginal bone level and the amount of root resorption were evaluated on standardized intraoral radiographs. The pockets and the clinical crown length was measured. The results showed that the true intrusion at the centre of resistance varied from 0 to 3.5 mm and was most pronounced when intrusion was performed with a base arch. The clinical crown length was generally reduced by 0.5 to 1.0 mm. The marginal bone level approached the cementoenamel junction in all but six cases all cases demonstrated root resorption varying from 1 to 3 mm. the total amount of alveolar support-that is, the calculated area of the alveolar wall-was unaltered or increased in 19 of the 30 cases. The dependency of the results on the oral hygiene, the force distribution, and the perioral function was evaluated in relation to the individual cases. It was obvious that intrusion was best achieved when (1) forces were low (5 to 15 gm per tooth) with the line of action of the force passing through or close to the centre of resistance, (2) the gingiva status was healthy, and (3) no interference with perioral function was present.

Michael McFadden (1989)[73] described that apical root shortening is one of the most common complications of orthodontic treatment. Force magnitude has been suggested as an important factor. Studies on the occurrence of root resorption show equivocal results. This study was to assess the relationship between intrusion with low forces (25 gm) using utility arches in the bio progressive technique and root shortening. The results shows root shortening was found to be an average of 1.64 mm for maxillary incisors and 0.61 mm for mandibular incisors. This study concluded that the intrusion with the utility arch technique is not related to amount of root shortening. The degree of root shortening was distinctly higher in the maxilla when compared to mandible. In general, treatment time was the most significant factor for occurrence of root shortening.

Marc vandenbulke (1990) [70] did a research to attain a better understanding of the initial reaction forces induced by an intrusion mechanism (acting on the anterior teeth) on the posterior unit and to examine how these forces can be neutralized. The experiments were performed on the dentition of a dry human skull and initial tooth displacements were recorded by means of two laser measuring techniques, namely holographic and the laser reflection technique. It was established that of all reaction forces induced by the intrusion arch, distal tipping of the first molars is the most pronounced. A transpalatal bar connecting the teeth does not counteract this movement. The stabilization of the posterior unit with a transpalatal bar, buccal sectionals, and high-pull headgear demonstrated to be the most effective technique.

Stanley Braun (1995)[15] Modern orthodontics needs defined treatment goals. To achieve them, known force systems must be used to control the active units (teeth being moved) and the reactive units (anchorage teeth). This article discusses the methods of controlling the force systems through the variables of spring design and anchorage selection. Continuous and segmented arch treatment are compared in their ability to achieve optimal and defined force systems with minimal side effects.

Michael S. Block (1995)[12] developed a new device to provide anchorage for orthodontic tooth movement. It is a disk, textured and hydroxyapatite coated on one side, with an internal thread on the other side. It is placed on palatal bone and, after integration, can be connected to teeth for anchorage. This article reviews a dog study representing unilateral tooth movement towards the "onplant" and a monkey study mimicking its use to anchor the molars for anterior retraction.

Christopher Parker (1995)[54] did a retrospective study of 132 treated orthodontic cases presenting at least 70% overbite was conducted using dental casts and lateral cephalometric radiographs taken before and after treatment. These were 61 Class I, 27 Class II, Division 1, and 44 Class II, Division 2 malocclusion patients. Six different treatment methods for the correction of the deep bite were compared. On the basis of the analysis of cephalometric measurements, no statistically significant differences were observed between the various treatment mechanics in the correction of the deep bite. Only in the Class II, Division 2 sample, total anterior face height increased significantly ($p < 0.01$) with all treatment modalities. The data were then grouped according to Angle classification Irrespective of the type of mechanics used. Within each system of classification, the changes from before to after treatment were statistically significant for almost all of the cephalometric measurements. These significant changes were due to both expected growth and orthodontic treatment. The treatment of overbite primarily affected the proclination of incisors and the extrusion of molars.

Greg Costopoulos (1996)[24] developed a new radiographic method for measuring changes in root length. With this technique, orthodontic intrusion was examined as a potential cause of apical root resorption of maxillary incisors. Intrusion measured at the center of resistance of the central incisor averaged 1.9 mm. The amount of resorption was not associated with the amount of intrusion. Results of this study seem to indicate that intrusion with low forces can be effective in reducing overbite while cause only a small amount of apical root resorption.

Shroff B et al (1997)[63] described a method of correcting deep overbite in patients with flared incisors, incorporating extraction or non extraction protocols. He focussed on the biomechanical aspect of three piece base arch and on the principle of how intrusive forces can be used for retraction. He claimed that the three-piece base arch assured a predictable, reproducible and statistically determinate force system with minimal chair side adjustments.

Ryuzo Kanomi (1997)[35] reported a case of 44-year-old male patient with the pain on the maxillary incisal papilla due to traumatic bite from lower incisors.

The treatment plan was to intrude the mandibular incisors. After four months , the mandibular incisors was intruded by 6mm . there was no evidence of root resorption or any periodontal breakdown.

Akin-Nergiz (1998)[2] studied functional and morphologic reactions of peri-implant bone surrounding screw implants in three dogs by loading the implants with continuous forces of 2 N (about 204 gm) and 5 N (about 510 gm). Eight implants were inserted to an endosseous length of 12 mm and placed about 10 mm apart in the region of the lower premolars. Horizontal distraction with a force of 2 N (about 204 gm) for 12 weeks were given. The continuously loaded implants showed no significant displacement with any force level. The mobility of the fixtures increased slightly by about 1 Periotest value (PTV) at the end of the experiment. No significant peri-implant pocket could be seen in implants loaded by continuous or masticatory forces. Osseo integrated implants have potential as a firm osseous anchorage for orthodontic treatment and can withstand continuous horizontal forces of at least 5 N (about 510 gm) during a period of several months.

Berte Melsen (1999)[46] did a study on Macaca fascicularis. She specified that Direct and indirect resorption are perceived as reactions to an applied force. This is in contrast to the view of orthopaedic surgeons, who describe apposition as a reaction to loading of bone. A histomorphometric study of the circumalveolar bone reaction to a force system generating translation of premolars and molars of five Macaca fascicularis monkeys is evaluated. Three force levels (100 cN, 200 cN, and 300 cN) were applied for a period of 11 weeks. The results in the study was sterile inflammation attempting to remove ischemic bone under the hyalinized tissue. The apposition, according to the new hypothesis, be observed as a result of the bending of the alveolar wall produced by the pull from the Sharpey's fiber. The above suggested interpretation of tissue reaction would be shared with bone biologists.

Noriaki (2001)[75] in his study was to determine the location of the centre of resistance and the centre of rotation of the maxillary central incisors.The results showed that the location of the centre of resistance of the maxillary central incisor depends on the palatal bone level and is at around two-thirds of the palatal alveolar bone height, measured from the root apex. A greater moment-to-force ratio is required for any controlled movement of the maxillary incisors during retraction in patients with reduced palatal alveolar bone height. This study suggests a method for estimating the location of the centre of resistance.

Michael .R. Marcotte (2001)[15] The purpose of this article is to describe how an orthodontic mechanical plan can be applied with the segmented arch technique. The mechanical plan has been divided into an initial stage, an intermediate stage, and a finishing stage of treatment. The importance of the anteroposterior position of the T-loop retraction spring is stressed. The finishing stage of treatment is actually completed early-on because the preliminary bracket alignment stage ideally aims to align the teeth intra segmentally. A simulated mechanical plan for a patient is designed by using the terms and principles shown in the article.

Ivanoff (2001)[33] conducted a study on twenty-seven patients. 2 micro implants were placed each during implant surgery. One micro implant was blasted with 25 micron sized particles of TiO(2); the other was a turned surface. Before insertion the surface topography was characterized with an optical confocal laser profilometer. Titanium miniplates were fixed at the buccal cortical bone around the apical regions of the lower first and second molars on both the right and left sides. The lower molars were intruded about 3 to 5 mm, and open-bite was significantly improved with little if any extrusion of the lower incisors. No serious side-effects were observed during the orthodontic treatment. The system was also very effective for controlling the cant and level of the occlusal plane during orthodontic open-bite correction.

Ohmae and Kanomi (2001)[52] conducted a study to determine the anchorage potential of the titanium mini-implant for orthodontic intrusion of the mandibular posterior teeth. Six mini-implants were surgically placed around the mandibular third premolars on each side in 3 adult male beagle dogs. In 6 weeks, an intrusive force (150 g) was applied between inter radicular implants on the buccal and the lingual sites by closed coil springs which ran across the crowns of the third premolars. After 12 to 18 weeks of orthodontic intrusion, the animals were killed and their mandibles were dissected and prepared for histologic study. The morphometrical findings indicated that the calcification of the peri-implant bone on the loaded implants was equal to or slightly greater than those of the controls.

Charles Burstone (2001)[20] Correction of deep overbite can be accomplished in different ways depending on the treatment goals chosen for individual patients. The 2 primary methods of correction are intrusion of anterior teeth or extrusion of posterior teeth. Successful intrusion of the incisors depends on careful control of the force system used. Low force magnitude, force constancy, a properly selected single point of force application, and control of force direction are all important factors to consider. The design of the intrusion arch may be continuous, or a 3-piece intrusion arch may be selected depending on the needs of the patient. Alternatively, extrusion of posterior teeth may be indicated in patients who are still actively growing and who have short vertical facial dimensions.

N.Yoshida (2001)[74] determined the centre of resistance of the two and four incisor units were approximately at the same position, whilst that of the six tooth unit was observed to be more incisal. Clinically, this finding shows that translation can be achieved with a smaller amount of moment to force ratio in en masse retraction than in two or four incisor retraction. The results also indicate that the location of the centre of resistance of the anterior segment during retraction may depend on the palatal alveolar bone height, rather than on the labial alveolar bone height.

Becker and Sennerbye (2002)[7] conducted a study on the clinical and histologic findings for smooth-surfaced titanium turned micro implants which were placed in one stage and loaded after healing. Five one-piece micro implants were placed in a fully edentulous mandible. Three were placed in one stage and extended through the keratinized mucosa for 3 mm. After 3 months of healing, three test implants were loaded for an additional 3 months. He proposed that smooth-surfaced, titanium threaded micro implants placed in one stage and loaded for 3 months demonstrated excellent Osseo integration, with varying bone-to-implant contact.

James Baldwin (2003)[6] explained forces and moments applied during orthodontic treatment. He stated that there is a point where application of a single force would cause pure translation. This is called centre of resistance. In the parabolic root it should lie about four tenths of the distance from the alveolar crest to the root apex. If there is a force in the periodontal membrane, and if the response to this distribution is uniform, the tooth will move bodily. If the force vector misses the centre of resistance, a varying stress distribution will allow the tooth either to tip or rotate. The tendency for tipping or rotation will occur in direct proportion to the distance of the vector from the centre of resistance.

Hee-moon kyung (2003)[39] stated that successful orthodontic treatment has always require intraoral anchorage with a high resistance to displacement. Extraoral traction can be an effective reinforcement, but exceptional patient cooperation is required. The size, bulk, cost, and invasiveness of prosthetic osseointegrated implants have limited their orthodontic application. Conventional bone screws can be used with bone plates to provide intraoral anchorage,but the screw heads fail to protect the gingiva from the impingement of ligatures or attached elastics and make it difficult to attach coil springs and other orthodontic forces .We have developed a narrow titanium micro-implant, the Absoanchor, that has a button shaped head with a hole for ligatures and elastomers. Its small diameter allows its insertion into many areas of the maxilla and mandible that were previously unavailable, such as between the roots of adjacent teeth

Yi Jane(2004)[21] conducted a study on nonsurgical orthodontic treatment in adult patient with deep overbite and underlying skeletal Class II discrepancy. He had a hypodivergent facial pattern, Class II Division 2 malocclusion, and traumatic deep overbite due to supereruption of the mandibular anterior teeth. Deep overbite was corrected by proclining the mandibular incisors; this helped to level the exaggerated curve of Spee. The posttreatment occlusion significantly improved, both functionally and esthetically, with stable interincisal contacts. However, the improvement in occlusion and esthetics was achieved at the cost of reduced periodontal support for the mandibular anterior teeth.

Liou (2004)[43] conducted a study on sixteen adult patients with miniscrews (diameter = 2 mm, length = 17 mm) as the maxillary anchorage to find out whether miniscrews are an absolute anchorage device. Miniscrews were inserted on the maxillary zygomatic buttress as a direct anchorage for en masse anterior retraction. Nickel-titanium closed-coil springs were placed for the retraction 2 weeks after insertion of the miniscrews. Miniscrews are a stable anchorage but do not remain absolutely stationary throughout orthodontic loading. They might move according to the orthodontic loading in some patients. To prevent miniscrews hitting any vital organs because of displacement, it is advised that they be placed in a non-tooth-bearing area that has no foramen, major nerves, or blood vessel pathways, or in a tooth-bearing area allowing 2 mm of safety clearance between the miniscrew and dental root.

Cope JB (2005)[22] The first successful screw shaped implant used exclusively for orthodontic anchorage was reported in 1983. In this report maxillary incisor intrusion was attained in a deep-bite patient with a miniscrew for anchorage. Since that time many miniscrew designs have been developed, and there has been a dramatic increase in use and popularity. It has been argued, however, that their utilization has preceded a thorough understanding of the biology involved and their mechanical potentials.

Huda Al-Buraiki (2005)[3] stated that correction of deep overbite with subsequent achievement of long-term stability is difficult and he investigated the effectiveness and long-term stability of overbite correction with incisor intrusion mechanics. The mechanics used were effective in overbite correction. During the posttreatment period, overbite increased by 0.7 mm. Although this change was statistically significant, the amount was small and is considered clinically insignificant, given the severity of the overbite pretreatment. Furthermore, a net overbite correction (T3-T1) of 3.3 mm and postretention overbite on 2.6 mm is an excellent clinical outcome.

Mihri (2005)[5] conducted a study to compare the effects of two different arches, the Connecticut Intrusion Arch (CIA) and the Utility Intrusion Arch (UIA). A total of 20 patients (15 girls and 5 boys) having Class I or Class II malocclusions with deep bite were divided into two groups. Lateral cephalograms were obtained before treatment and after intrusion of upper incisors. The CIA and UIA were both effective in the intrusion of incisors and can be used successfully in the treatment of deep overbite. Extrusion of molars increased the anterior and the posterior facial heights so additional anchorage mechanics should be used in order to minimize this effect in dolichofacial patients. The skeletal, dental and soft tissue effects of the appliances are almost the same. Being the last generation of intrusion appliances, CIA is made of super elastic Nitinol and provides an alternative for the treatment of deep overbite. It does not have any different effect than the UIA, but being a prefabricated appliance, chair time is reduced which is an advantage for both the patient and the clinician.

Antonio Costa (2005)[23] in this study ideal sites for the placement of temporary anchorage devices (TADs), the depths of the hard and soft tissues of the oral cavity were evaluated in 20 patients. The bone depth was quantified by volumetric computed tomography (VCT). The mucosal depth was quantified by a needle with a rubber stop. The results indicate that bone thickness will allow TADs 10 mm in length only in the symphysis, retromolar, and palatal premaxillary regions. TADs 6 to 8 mm in length can be placed in the incisive fossa, in the upper and lower canine fossae. These TADs (4-5 mm) only engage monocortically, whereas the others have the ability to engage bicortically. When placing TADs in mobile alveolar mucosa, the results suggest that a transmucosal attachment may be required to traverse the thickness of the soft tissue.

Van Steenburg (2005)[71] determined the magnitude of intrusive force to the maxillary incisors influences the rate of incisor intrusion or the axial inclination, extrusion, and narrowing of the buccal segments. Twenty patients between the ages of nine and 14 years who needed at least two mm of maxillary incisor intrusion were assigned to one of two equal groups. In group 1 patients, the teeth in the maxillary anterior segment were intruded using 40 g, whereas in group 2 patients, 80 g was used. Records were taken from each patient at the beginning and end of intrusion. There was no statistically significant difference between the 40- and 80-g groups in the rate of incisor intrusion, or the amount of axial inclination change, extrusion, and narrowing of the buccal segments.

Birte Melsen (2005)[18] described about the evolution of implants, about the material and design, indications of the implants, about the selection of size and location of the implants,insertion procedure and also about the screw related problems and patient related problems.

Ioanis (2005)[32] gave the review about the location of CR of maxillary incisor given by different authors. Christiansen and Burstone (1969), as well as Burstone and Pryputniewicz (1980) report that the CR lies at a point that equals 40% of the tooth root length measured from the alveolar crest in a two-dimensional model with parabolic root shape or at 33% of the tooth root length in a three-dimensional model with parabolic root shape. Nikolai (1974) locates the CR at a distance equal to 45% of root length in a two-dimensional model made for theoretical analysis, whereas Davidian (1971) places it at 40% and Halazonetis (1996) at 42%.

Major PW (2005)[51] did a meta-analysis to quantify the amount of true incisor intrusion attained during orthodontic treatment. He concluded that true incisor intrusion is achievable in both arches, but the clinical significance of the magnitude of true intrusion as the sole treatment option is questionable for patients with severe deepbite. In nongrowing patients, the segmented arch technique can produce 1.5 mm of incisor intrusion in the maxillary arch and 1.9 mm in the mandibular arch.

Camilllo Morea (2005)[49] designed a guide to place mini-implant Optimal positioning has always been critical to the effectiveness of dental implants. Critical factor in orthodontic mini-implant placement is the angle of insertion. Recommended angles of the implant to the long axes of the teeth have ranged from 10-20º in the mandible and from 30-40º in the maxilla. The procedure is illustrated in a 13-year-old female patient who presented with a Class II, division 1 malocclusion and was treated with four first bicuspid extractions. A headgear was prescribed to provide anchorage, but was not effective due to poor compliance. Orthodontic mini-implants were then used to complete the upper anterior retraction without loss of anchorage.

Cattaneo P.M et al (2005)[18] attempted to determine the impact of the modeling process on the outcome from FE analyses and relate the findings to the current concepts of orthodontic tooth movement. He evaluated the influence of morphology, material properties, and boundary conditions on the outcome of FE analyses. He demonstrated through FEM analysis that loading of the periodontium cannot be explained in simple terms of compression and tension along the loading direction. Tension in the alveolar bone was far more predominant than compression.

Ulricke Schutz (2006)[61] in this study they evaluated the long-term stability of corrected deep bite and mandibular anterior crowding in a sample of 62 subjects (30 patients and 32 controls). The patients started treatment at a mean age of 12.2 years (SD 1.56).Treatment was found to have normalized the overbite and overjet and to have eliminated the space deficiency in the mandibular anterior region. At T4, there was a minor relapse in overbite in the treatment group (mean 0.8 mm). In the control group, the overbite underwent reverse development (bite opening by 0.7 mm) during the same period. The available mandibular incisor space, however, was 0.9 mm in the treatment group and 1.8 mm in the control group. The long-term stability of the treatment results was good.

Tae –woo Kim (2006)[36] conducted a study on a boy, aged 10.5 years, with a Class II molar relationship and a very deep overbite, complaining of a gummy smile and anterior crowding, was treated nonextraction with a mini-implant and Twin-block and edgewise fixed appliances. Severely extruded and retroclined maxillary incisors were intruded and proclined with a nickel-titanium closed-coil spring anchored to a mini-implant and segmented wires; this resolved the gummy smile and deep overbite efficiently without extruding the maxillary molars or opening the mandible. The mandibular incisors were proclined without direct orthodontic force during intrusion of the maxillary incisors; this helped the nonextraction treatment of mandibular incisor crowding. The Twin-block appliance with high-pull headgear induced mandibular growth, restrained maxillary growth, and changed the canine and molar relationship from Class II to Class I. The patient’s overbite and overjet were overtreated, and, 1 year postretention, the patient maintained a good overbite and overjet.

Shingo Kuroda (2007)[38] this study evaluation of the clinical usefulness of miniscrews as orthodontic anchorage was done Examination of their success rates, analyzed factors associated with their stability, and evaluated patients' postoperative pain and discomfort with a retrospective questionnaire. The success rate for each type of implant was greater than 80%. Most patients who received titanium screws or miniplates with mucoperiosteal-flap surgery reported pain, but half of the patients receiving miniscrews without flap surgery did not report feeling pain at any time after placement. In addition, patients with miniscrews reported minimal discomfort due to swelling, speech difficulty, and difficulty in chewing. Miniscrews placed without flap surgery have high success rates with less pain and discomfort after surgery than miniscrews placed with flap surgery or miniplates placed with either procedure.

Kevin (2007)[76] studied the concept of orthodontic anchorage and focuses on ways skeletally derived anchorage. A brief history of the different skeletal anchorage systems to date is given. The article gives an emphasis on the use of one particular skeletal anchorage technique—the micro-implant—to assist with orthodontic anchorage and active tooth movement. Advantages and disadvantages of this new technique are discussed. An illustration of the use of micro-implants is given with reference to a case where they have been used in a novel manner to provide distal movement of maxillary molars.

Toru Deguchi (2008)[28] compared the effect of incisor intrusion, force vector, and amount of root resorption between implant orthodontics and J-hook headgear. The predictable force vector was analyzed in the horizontal and vertical directions in both groups. Root resorption was also measured on periapical radiographs. In the implant group, significant reductions in overjet, overbite, maxillary incisor to palatal plane, and maxillary incisor to upper lip were observed after intrusion of the incisors. In the J-hook headgear group, significant reductions in overjet, overbite, maxillary incisor to upper lip, and maxillary incisor to SN plane were observed after intrusion of the incisors. There were significantly greater reductions in overbite, maxillary incisor to palatal plane, and maxillary incisor to upper lip in the implant group than in the J-hook headgear group. Furthermore, significantly less root resorption was seen in the implant group compared with the J-hook headgear group. the maxillary incisors were effectually intruded by using miniscrews as orthodontic anchorage without patient cooperation. The amount of root resorption was not affected by activating the ligature wire from the miniscrew during incisor intrusion.

Madhur upadhyay (2008)[10] in their case report described the treatment of a 16 year-old post pubertal male patient with a severe Class II division 2 malocclusion and 100% deep bite. In the first phase of treatment, a ‘Jones-Jig’ molar distalization appliance was used to distalize the maxillary molars by more than 6 mm, to achieve a Class I molar relation. In the second phase of treatment, mini implants were inserted between the roots of the maxillary lateral incisor and canine to intrude all the maxillary anterior teeth en masse in a single step. Four millimetres of intrusion was achieved. The implants remained stable throughout treatment. In the mandibular arch the incisors were proclined to alleviate the severe crowding. Good overjet and overbite was achieved and has been maintained one year after completion of active orthodontic treatment.

Sofia (2008)[31] The aims of this review are twofold, firstly, to give an overview of the general and local risk factors when using temporary anchorage devices (TADs) and the requisites for placement and, secondly, to demonstrate the orthodontic indications of various TADs. General risk factors are factors concerning general health. Bone quality and oral hygiene are local risk factors. Aspects of the placement procedure discussed were: primary stability, loading protocols, pre-drilling diameter and whether or not to make an intra-oral incision.

Hugo (2008)[27] skeletal anchorage now makes it possible to intrude one or more teeth. If miniscrews are used, they should be inserted at a distance from the roots, according to the amount of intrusion needed. In such a location, the head of the screw is usually surrounded by mobile mucosa, which increases the risk of bacterial infiltration and local infection. With modified miniplates, the screws can be inserted at a safe distance from the root apex, so that the extension will perforate the mucosa close to the mucogingival margin, causing less mobility of the surrounding soft tissues. This reduces the risks of infection, bone loss, and screw loosening. Moreover, a connecting bar with a round section facilitates oral hygiene in the area where it penetrates the soft tissues. Another disadvantage of using miniscrews for intrusion is the connection between the skeletal anchor and the orthodontic appliance. In the technique stated here, only one bone anchor is needed. Because of the rigidity of the skeletal anchorage and the firm connection to the tooth with a nearly full-size wire in the headgear tube, no auxiliaries are required. In the anterior segment, one or more teeth may be intruded along a rigid connection to a bone anchor on the paranasal ridge. A conventional auxiliary intrusion arch should be engaged in the fixation unit of the bone anchor. This will eradicate reaction forces and unwanted movement of the posterior teeth during intrusion.

Iosif sifakakis (2009)[64] evaluated the comparative intrusive forces and torqueing moments in the sagittal plane generated during anterior intrusion using different incisor intrusion mechanics in the maxillary and mandibular anterior teeth. Five wire specimens were used for each of the following intrusive arches: non–heat-treated, 0.016 x 0.016-inch blue Elgiloy utility arch, 0.017 x 0.025-inch TMA utility arch, and 0.017 x 0.025-inch TMA Burstone intrusion arch. The wires were constructed according to the specifications given by their inventors and were inserted on bracketed dental arches on Frasaco models, segmented mesial to the canines. Simulated intrusion from 0.0–1.5 mm was performed on the Orthodontic Measurement and Simulation System (OMSS), and forces and moments were recorded at 0.1 mm vertical displacement increments. All measurements were repeated five times for each specimen, and maximum values recorded at 1.5 mm for all wires were used for all statistical evaluations.The 0.017 x 0.025-inch TMA Burstone intrusion arch exerted the lowest intrusive forces,followed by the 0.017 x0.025-inch TMA utility and the 0.016 x 0.016-inch blue Elgiloy utility arch. The lowest anterior moment inthe sagittal plane in this experiment was generated from the 0.017x 0.025-inch TMA Burstone intrusion arch and the intrusive forces, as well as the generated moments, were always higher in the mandible.

Birte Melsen (2009)[11] stated that the primary goal of orthodontic treatment was to position the maxillary left premolar and molar for prosthetic reconstruction with one premolar implant behind the maxillary left canine. The patient would then have full occlusion on two pairs of premolars and one pair of molars on the left side. This plan involved mesial movement of the extruded maxillary left second molar into the neutral position of the extracted first molar, requiring extradental anchorage. The tooth would be intruded, and space would be created for the implant in the left first premolar region through distal movement of the second premolar. The distal relation of the maxillary and mandibular right first molars and the neutral canine relations would be maintained. Minor spaces are left distal to both maxillary canines because of the tooth-size discrepancy. The smile would be improved through closure of the anterior diastema, levelling and alignment, and coordination of the dental midlines. Careful biomechanical planning is needed to determine how, when, and where the skeletal anchorage should be incorporated into orthodontic treatment.Anchorage problems should not be addressed simply by increasing the number of miniscrews, nor should TADs be used as a crutch to compensate for problems due to poor planning.

Omar Polat (2009)[56] investigated if true incisor intrusion can be achieved using miniscrews. Eleven patients (three males and eight females; mean age: 19.8± 4.8 years) with normal vertical dimension showing a pre-treatment deep bite of 5.9 ± 0.9mm and a 'gummy' smile were enrolled in the study. After levelling of the maxillary central and lateral incisors with a segmental arch, an intrusive force of 80 g using closed coil springs was applied from two miniscrews placed between the roots of the lateral and canine teeth. The amount of incisor intrusion was evaluated on lateral cephalometric head films taken at the end of levelling (T1) and at the end of intrusion (T2). The mean upper incisor intrusion was 1.92 mm and the mean overbite decrease 2.25 ± 1.73 mm in 4.55 months. Upper incisor angulation resulted in a 1.81 ± 3.84 degree change in U1-PP angle and a 1.22 ± 3.64 degree change in U1-NA angle. However, these were not statistically significant. True intrusion can be achieved by application of intrusive forces close to the centre of resistance using miniscrews.

Rekha Mitlal (2009)[48] conducted clinical study to quantify the amount of the true incisor intrusion achieved during orthodontic treatment using mini-implants (TADs) to correct the dental deep overbite in adult patients, as well as to assess the overall treatment time period in achieving a true incisor intrusion The treated group consisted of fifteen subjects with a dental deep bite of at least 4mm (mean overbite, 4.44mm and mean age 21 years). After initial alignment of anterior teeth, a mini-implant was placed below the anterior nasal spine and was used to intrude the maxillary incisors on a segmented arch wire connecting the four incisors and molars together.The results of the study revealed that mini-implants (TAD's) serve as an efficient source of anchorage for achieving true incisor intrusion of anterior teeth in deep overbite correction. It does not have any side effects on the posterior segment, especially in patients with unfavourable growth patterns and non-growing patients.

Deepak chandran (2009)[19] stated that a gummy smile is probably one of the most Commonest causes of an unaesthetic smile. Causes include overeruption of maxillary anterior teeth and maxillary vertical excess. Intrusion of maxillary anterior teeth with Orthodontics and Le forte I superior repositioning may form a part of the solution. Recently the use of micro implants have improved the smile esthetics of borderline surgical cases by allowing the Orthodontist to intrude teeth more than what was possible with conventional Orthodontics.

Dr. Krishna Nayak (2010)[50] studied Seven patients with deep overbite and with increased upper incisor/anterior gingival display were the sample for our study. After levelling of the maxillary central and lateral incisors with a segmented arch, an intrusive force of 50 gms using Niti closed coil springs was applied from a mini-implant placed between the roots of the two central incisors. The amount of intrusion was evaluated on lateral cephalograms taken at the end of levelling (T1) and 4 months later (T2).The mean incisor intrusion achieved with mini-implants was 3.29mm . The mean molar extrusion seen with mini-implants was 0.29. The mean of the change in incisor inclination is 0.14degrees . The results of this study revealed that true incisor intrusion can be achieved with the use of mini-implants.

Omar Polat (2011)[55] The aim of this prospective study was to compare the effects of incisor intrusion obtained with the aid of miniscrews and utility arches. Twenty-four patients (10 male, 14 female) with a deepbite of at least 4 mm were divided to 2 groups. In group 1, 13 patients (3 male, 10 female) in the postpubertal growth period were treated by using miniscrews; in group 2, 11 patients (7 male, 4 female) were treated with utility arches. Lateral cephalometric headfilms were taken at the beginning of treatment and after intrusion for the evaluation of the treatment changes. Intrusion lasted 6 months for group 1 and 6months for group 2. The changes in the center of resistance of the incisors were 1.7for group 1 and 0.86 for group 2). In the miniscrew group, the incisors were protruded 0.79mm relative to pterygoid vertical and 3.8 relative to the palatal plane. In group 2, the incisors showed 3.9of protrusion relative to pterygoid vertical and 13.55 relative to the palatal plane. The maxillary first molars showed significant distal tipping in group 2 .Unlike with utility arches, true maxillary incisor intrusion can be achieved by application of intrusive forces close to the center of resistance by using miniscrews with no counteractive movements in the molars.

Neslihan(2012)[62] the purpose of this study was to compare the skeletal and dental effects of 2 intrusion systems involving mini-implants and the Connecticut intrusion arch in patients with deepbites. Both the Connecticut intrusion arch and the mini-implant intrusion systems successfully intruded the 4 maxillary incisors. Although the movement of the maxillary molars led to the loss of sagittal and vertical anchorages during intrusion of the incisors in the Connecticut intrusion arch group, these anchorages were maintained in the implant and control groups.

Varlık S.K et al (2013)[72] investigated the long-term stability of deep overbite correction with mandibular incisor intrusion with utility arches in adult patients (Pretreatment, posttreatment, and 5-years postretention lateral cephalograms of 31 patients). Post treatment changes included significant decreases in overjet and overbite, significant retroclination and retraction of the maxillary incisors. Significant amount of protrusion, proclination and intrusion of the mandibular incisors were observed at posttreatment. At postretention, did show statistically significant but clinically insignificant increases in overjet and overbite. He concluded that utility arch can be considered effective and stable for correcting deep overbite by mandibular incisor intrusion in non-growing patients.

Jain R.K et al (2014)[34] evaluated the efficiency of producing intrusion of maxillary incisors using mini implants, utility arch and j- hook headgear. 30 subjects divided into 3 Groups equally. Group 1- mini implant anchorage, Group 2 - J- hooks headgear and Group 3- utility arch were used for intrusion. Lateral cephalograms were taken before treatment and at the end of intrusion. Five cephalometric parameters were used to measure the amount of intrusion attained in each Group. Mini implant group displayed a mean average intrusion of 2.1 mm, the mean average intrusion attained through J hooks was 0.7 mm, and the mean average intrusion achieved by utility arch was 1.4 mm with a side effect of 0.75 mm of molar extrusion. He concluded when compared with the other methods mini implants will produce true intrusion without any other side effects.

Gupta R.K et (2016)[30] calculated the stress and displacement produced at apex of maxillary central incisor for three different magnitudes of intrusive forces (5, 10, 15gm) at three different inclinations; Group I (56°), Group II (51°), Group III (61°) by 3-D finite element method. Maximum amount of stress and displacement was detected at apex for 15gm of vertical force (Fv) in and minimum for 5gm. For every Fv, stresses obtained were maximum for Group II > I > III. The resultant force (Fr) were directly proportional to Fv. Fr and horizontal force (Fh) were maximum for Group II > I > III for each Fv. Stresses were found concentrated at a smaller area apically. The author concluded it is always advisable to use lighter forces for intrusion, thereby making it more comfortable for the patient.

Saga A.Y et al (2016)[59] investigated the distribution patterns and magnitude of compressive stress in the periodontal ligament (PDL) by simulation of orthodontic intrusion of maxillary incisors. Different points of force application through FEM were created from anatomic 3D models reconstructed from cone-beam computed tomography scans. The various points of force application selected were: centered between central incisors brackets; bilaterally between the brackets of central and lateral incisors; bilaterally distal to the brackets of lateral incisors; and bilaterally 7 mm distal to the center of brackets of lateral incisors. Stress concentrated at the PDL apex region, irrespective of the points of orthodontic force application. Forces bilaterally distal to the brackets of lateral incisors resulted in more balanced compressive stress distribution.

Belludi A et al (2016)[8] in his article addressed various conventional clinical intrusion mechanics and especially intrusion using mini-implants for intrusion of maxillary anteriors. True intrusion is limited principally by inadequate dental anchorage with conventional intrusion mechanics.The intrusion arch develops an active intrusion force against the anterior teeth, it simultaneously develops an extrusive force and tip- back moment against the anchor molars.

Both, Bilateral Mini-implants and Single mini implant placed below the anterior nasal spine serve as an efficient and biologically sound method source of anchorage for achieving true incisor intrusion of anterior teeth.

Sahu S et al (2017)[66] discussed an review article the biomechanics of intrusion in orthodontics and various methods to achieve the intrusion tooth movement successfully without causing any deleterious effect to the tooth. She also presented the types of intrusion, their indications and contraindications in clinical scenario along with the use of various removable and fixed appliances and their modifications to achieve intrusion is discussed and reviewed at length.

Bhat M et al (2017)[10] compared the amount of apical root resorption in orthodontic patients undergoing maxillary anterior intrusion using utility arches and mini screws; and to compare the efficacy of mini screws and utility arches in reducing over bite. 20 patients, divided in two groups. Group A comprised of 10 patients in whom titanium mini-screws were used Group B comprised of 10 patients in whom utility arches made of 0.017 × 0.25″ TMA were used. The pre and post radiographic images were measured from incisal tip to the root apex with the help of intrascan DC software. The author observed though root resorption was seen in both group, higher resorption was seen in mini implant group than utility arch group. Mini implants were more effective in reducing the overbite when compared to utility arches.

Del Castillo McGrath M. G et al (2018)[29] evaluated by means of the finite element method, initial tooth displacement and periodontal stress distribution using various mandibular anterior intrusion mechanics using Miniscrews. were used as skeletal anchorage devices. 3-dimensional reconstruction of the mandible and the mandibular anterior dentition were made using CBCT scans. Changes in the location of the miniscrews and loading points on the archwire created 14 scenarios. He denoted that, in addition to disto-intrusive vectors, 4 loading points on the archwire were necessary for pure intrusion and uniform distribution of periodontal stress in the 6-tooth scenarios. Uniform periodontal stress distribution and minimum buccolingual displacements were generated when a pair of miniscrews distal to the canine roots, 1 screw per side, and directing 4 loading points on the archwire generates. Bone width and attached gingiva level played significant roles in the clinical viability of the proposed virtual scenarios.

Bohara P et al (2018)[14] evaluated the stress distribution and displacement of maxillary anterior teeth during en masse intrusion and retraction on force application with different combinations of mini-implants and retraction hooks using four different finite element models of maxillary arch. Tensile stresses were seen in the cervical region. Nature of stresses changed from tensile to compressive from cervical area to apical area. Various tooth displacements suggested that different combinations of mini-implants and retraction hooks affected the direction of the tooth movement.

Ahuja S (2018)[1] studied the biomechanical effects of the three-piece intrusion arch and Kalra simultaneous intrusion and retraction arch (K-SIR) on simultaneous intrusion and retraction of maxillary anterior teeth. 3D analysis of stresses and displacement of the anterior and posterior teeth was done using the finite element method (FEM). The von Mises stress, principal stress on PDL and alveolar bone, change in the inclination of incisors and initial displacement were analysed. Stresses in cortical bone were greater than cancellous. The three-piece intrusion arch displayed uniform stress distribution compared to K-SIR arch. Although FEM cannot reflect actual biological responses within the human body to orthodontic forces, based on these findings, the three-piece intrusion arch showed better stress distribution and controlled tooth movement than the K-SIR arch.

Tilekar N.R (2019)[67] compared the amount and rate of maxillary incisor intrusion by varying position of mini-implants. 24 subjects having deep bite were assigned to two groups: Group I with single mini-implant was placed in the alveolar region between the roots of maxillary central incisors and a force of 60 grams was applied with elastic chain tied. In Group II where mini-implants were placed bilaterally in the alveolar region between the roots of maxillary lateral incisors and canines and a force of 30 grams (total 60 grams) was applied on each side. Lateral cephalograms taken before intrusion and 4 months after intrusion. No significant difference in the amount and rate of intrusion between the two groups. Minimal molar extrusion was seen in both the groups but the difference was not statistically significant. Both the methods are effective but two mini-implants are preferred as they cause relatively less proclination of maxillary incisors.

Material and Methods

MATERIALS AND METHODS

A 3-dimensional finite element model of a maxillary arch and intact dentition with normal inclination, brackets and archwires were created.

The following components were created:

1) The maxillary arch with intact dentition was obtained from the computed tomography scan with a slice thickness of 0.5 mm.
2) The periodontal ligament
3) The alveolar bone
4) A standard conventional preadjusted edgewise brackets of 0.022 slot Roth prescription are used.
5) Three- piece intrusion arch
6) Two mini implants of 1.3x7mm diameter.

APPLIANCE DESIGN

- Group A: Segmental – Three piece intrusion arch

  Component (i)-Anterior 19x25 stainless steel (passive)

  Component (ii)- Posterior 17x25 TMA (active)

- Group B: Two mini implants of 1.3x7mm diameter (simulation) was placed on an either side between the lateral incisor and canine and ligature wire was used to deliver 70 grams of force (each side) from the mini implant to the base archwire

MODELLING:

The first step involved in the construction of three dimensional finite element model is modelling, which was done using a software called HYPERMESH. This software enables the models to be created and edited with ease and it represents the geometry in terms of points, lines, area and volume. The constructed smooth object can then be represented geometrically as elements.

THREE DIMENSIONAL MODELLING OF MAXILLARY DENTITION:

A three dimensional FE model of the maxilla was generated using volumetric data from the Computed Tomography scan images of the patient. The computed tomography images were taken in slices of 0.5 mm thickness.

The DICOM CT images was converted to STEP FORMAT using CREO parametric version 2.0. CREO parametric version 2.0 was then imported for geometrical clean-up of maxilla with geometrical modelling of three piece intrusion arch, two mini implants and archwire. The assembly of all the objects was done using the same software.

The final assembled CAD model, were then imported to HYPERMESH software, for the conversion of finite element model of the maxilla and the appliance as a whole.(Figure 1)

FINITE ELEMENT ANALYSIS:

This study was done using ABACUS 6.1 which can import models with 100%data transfer or with 0% data loss. Once imported the software can do an automatic meshing with defined material properties. The software establishes contacts automatically and specifically defines components between the contacts.

The constructed modelled images of maxillary arch with dentition, brackets and archwire was then imported to Work Bench and the relevant material properties were assigned. The material properties required are Poisson's ratio and Young's modulus for each component as given in below table (Table 1). Then the periodontal ligament is extracted as surface from the root of the tooth and thickness is assigned.

Table 1: Material properties of various components used in the study.

MATERIALS	YOUNG'S MODULUS (MPA)	POISSON'S RATIO
Tooth	20,000	0.30
Periodontal ligament	0.059	0.49
Alveolar bone	2,000	0.30
Bracket	200,000	0.30
Archwire	200,000	0.30

All these components were individually modelled and then assembled to create 3D finite element models of the maxilla depicting intrusion of four anterior teeth with ABACUS 6.1 Once all the images were imported,the software can do an automatic meshing with defined material properties. Then the models were converted to elements and nodes. The type of element used in our study was mid noded tetrahedron and the final total number of elements and nodes were established.

Once Meshing and contacts are defined the next process is to define Boundary conditions. Boundary condition means to define loads and restraints, so that the results can be reviewed.

A three dimensional finite element model of maxilla with three-piece intrusion arch and temporary anchorage device was finally obtained. The stress distribution and displacement was calculated with a different point of force application.

Group A: Three-piece intrusion arch with posterior component of 17x25 TMA was used as a loading arm to apply force for intrusion. The appliance was activated by giving a displacement of 140 grams in the loading arm, which is 70 grams of force on each side. The simulated stress and displacement of the FE model, during the analysis was assessed.(Figure 3)

Group B: Two mini implants of 1.3x7 mm was used. The ligature wire acts as a loading arm for force application. The ligature wire was attached from the mini implant to the base archwire. The appliance was activated by giving a displacement of 140 grams in the loading arm, which is 70 grams of force on each side. The simulated stress and displacement of the FE model, during the analysis was assessed. (Figure 4)

REFERENCE POINTS:

The measurement of both the groups was calculated using reference points such as root apex (RA) and incisal edge (IE) and was probed for displacement values in X- axis (transverse)Y-axis (sagittal) and in Z axis (vertical).(Figure 2a ,2b)

STATISTICS:

All statistical analysis was performed by using SPSS software. Descriptive statistics was done to evaluate the stress distribution and overall displacement of the dentition for both the groups.

Figures

FIGURE 1 : STL MODEL OF MAXILLA WITH MAXILLARY DENTITION

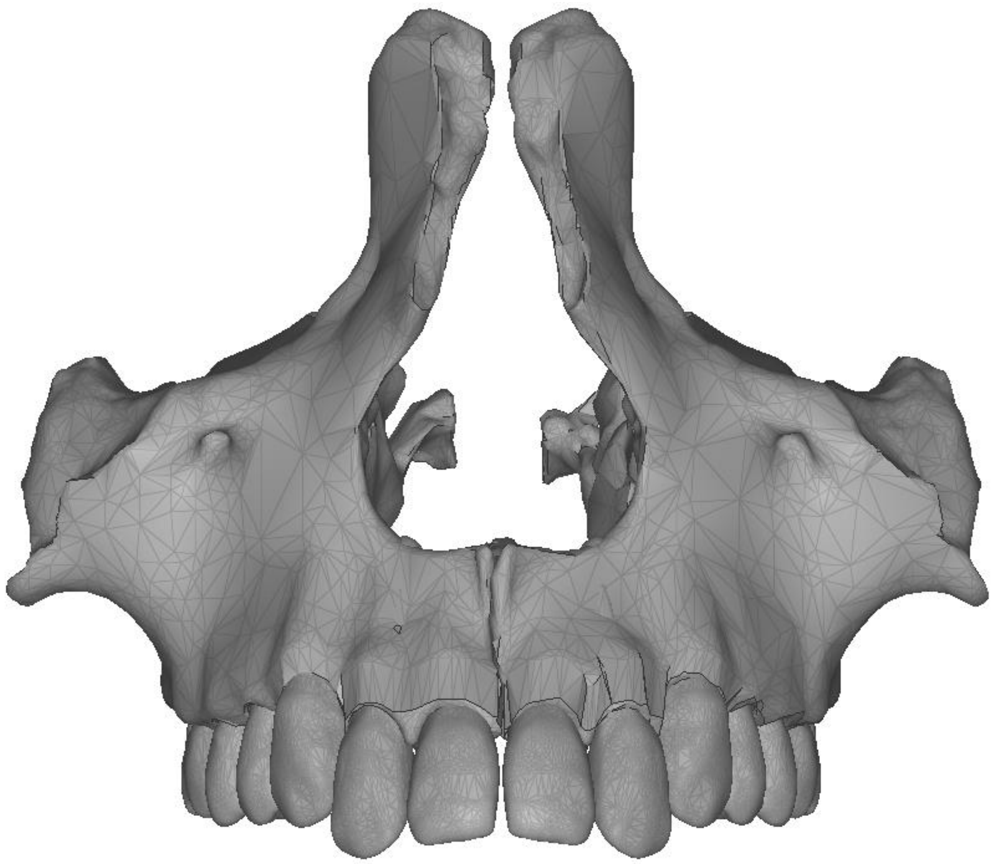


FIGURE 2a: REFERENCE POINTS MARKED AT THE INCISAL EDGES (IE)

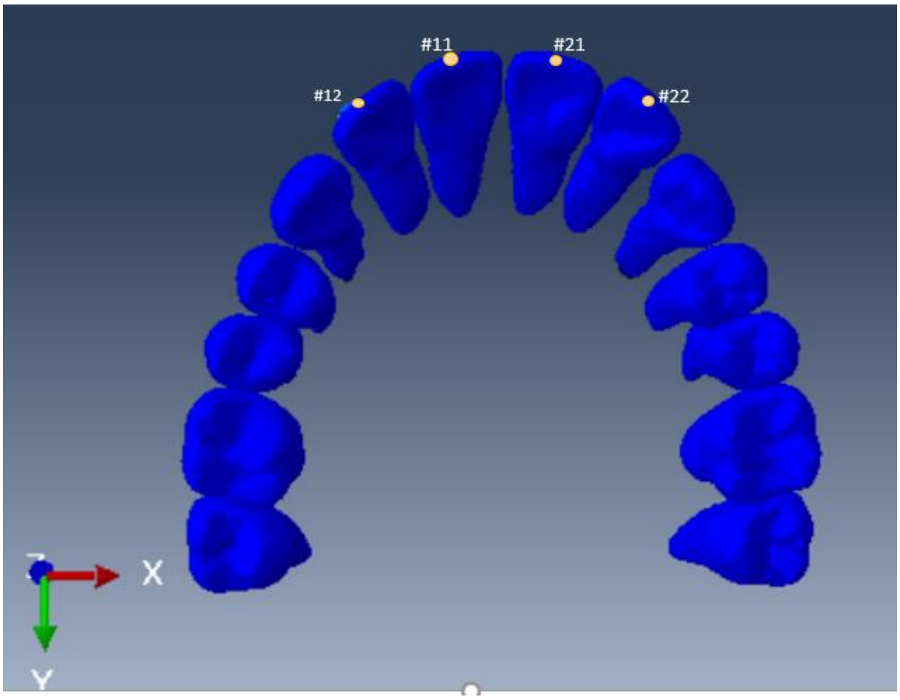


FIGURE 2b: REFERENCE POINTS MARKED AT THE ROOT APEX (RA)

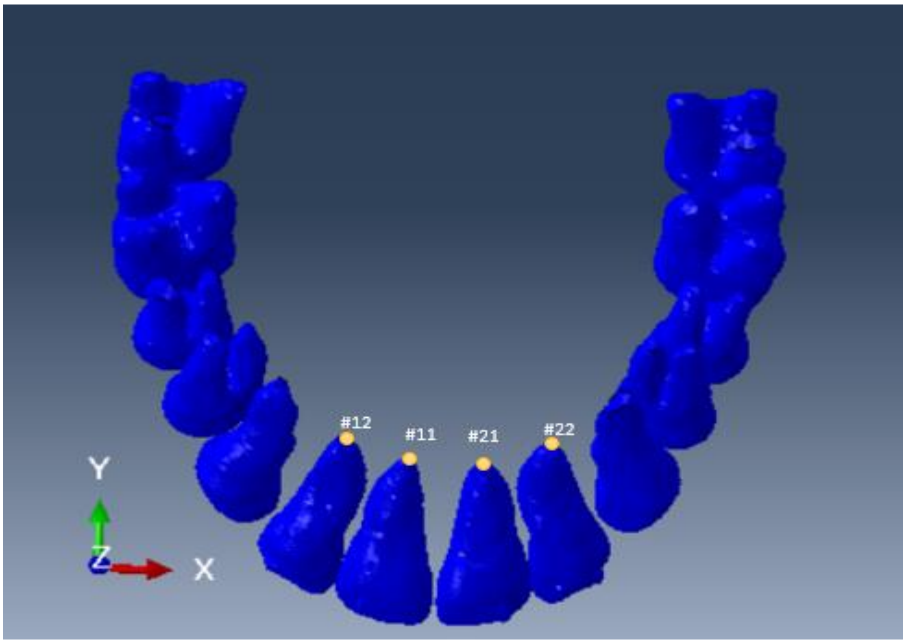


FIGURE 3: GROUP A - THREE-PIECE INTRUSION ARCH

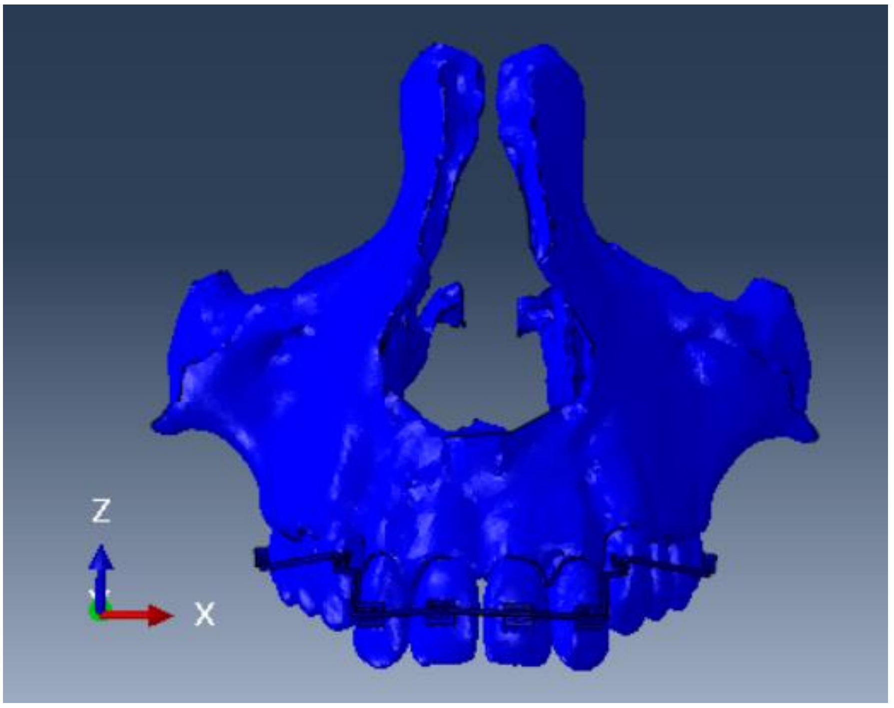


FIGURE 4: GROUP B - MINI IMPLANT ASSISTED INTRUSION

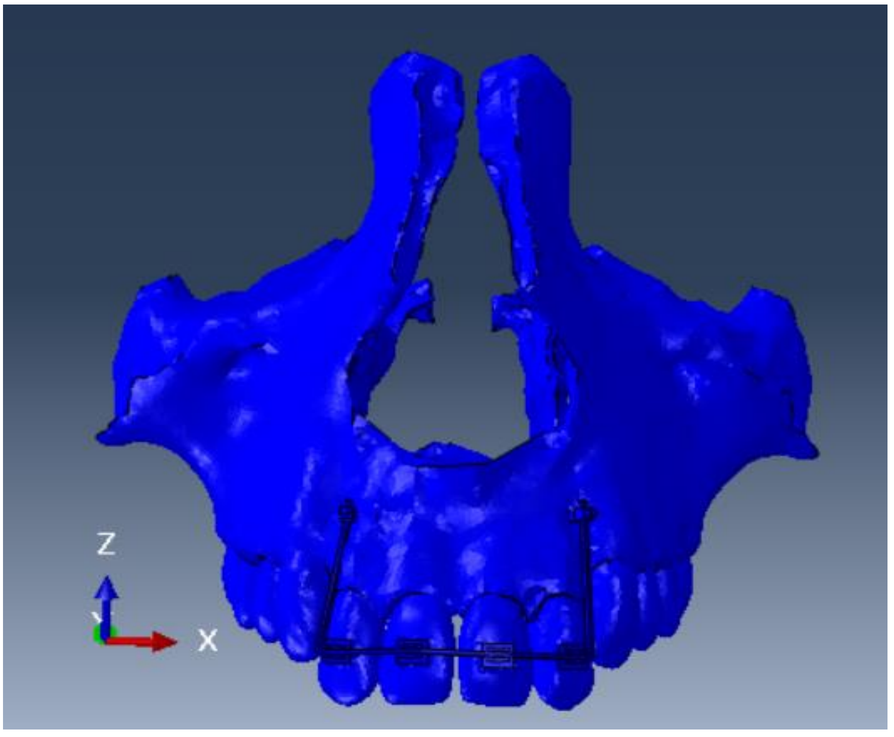


FIGURE 5a: VON MISES STRESS WITH THE THREE -PIECE INTRUSION ARCH (GROUP A)

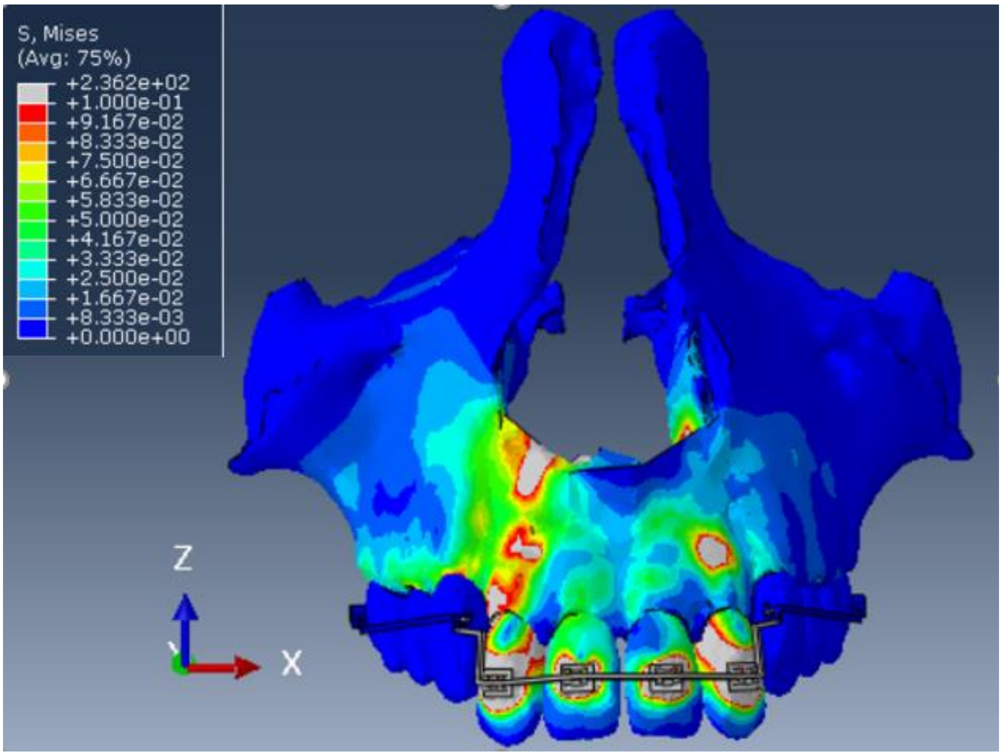


FIGURE 5b: VON MISES STRESS WITH PERIODONTAL LIGAMENT IN GROUP A

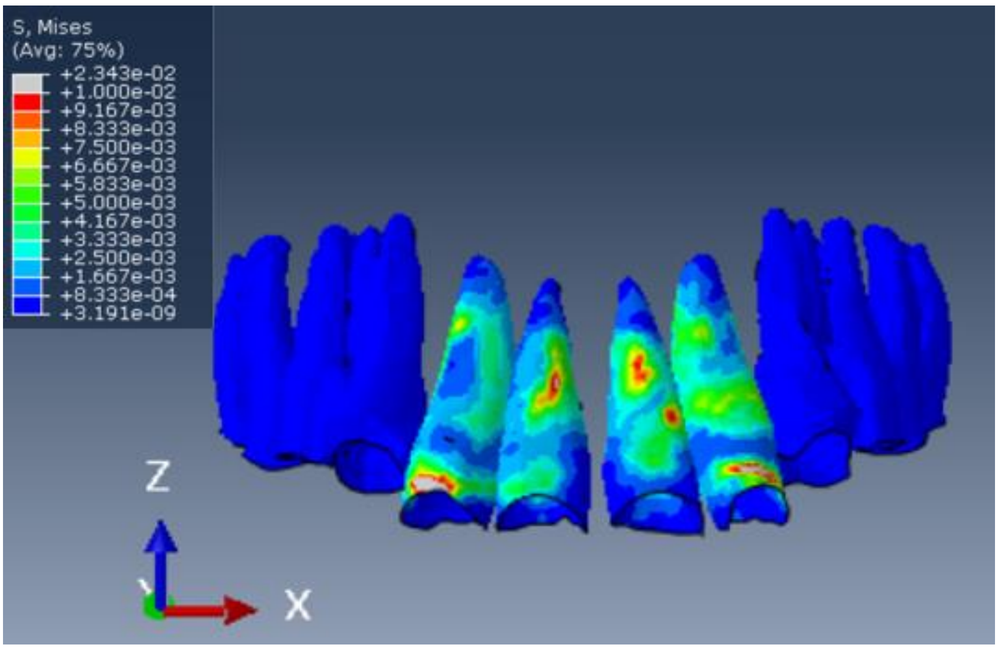


FIGURE 6a:VON MISES STRESS WITH MINI IMPLANT (GROUP B)

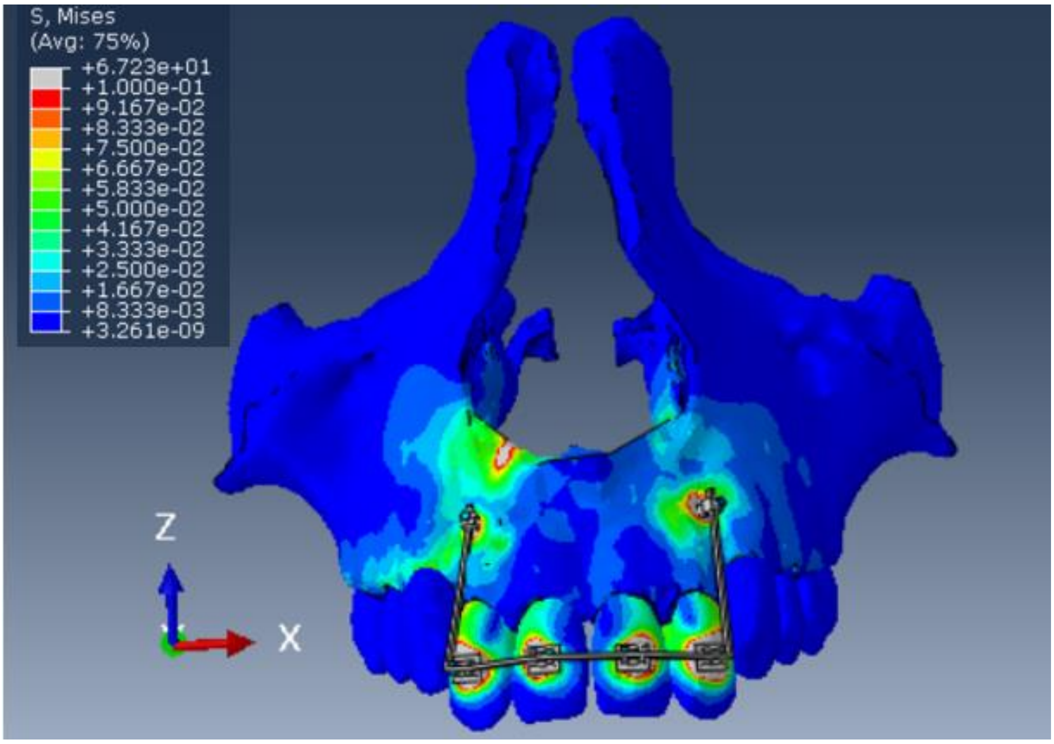


FIGURE 6b: VON MISES STRESS WITH PERIODONTAL LIGAMENT IN GROUP B

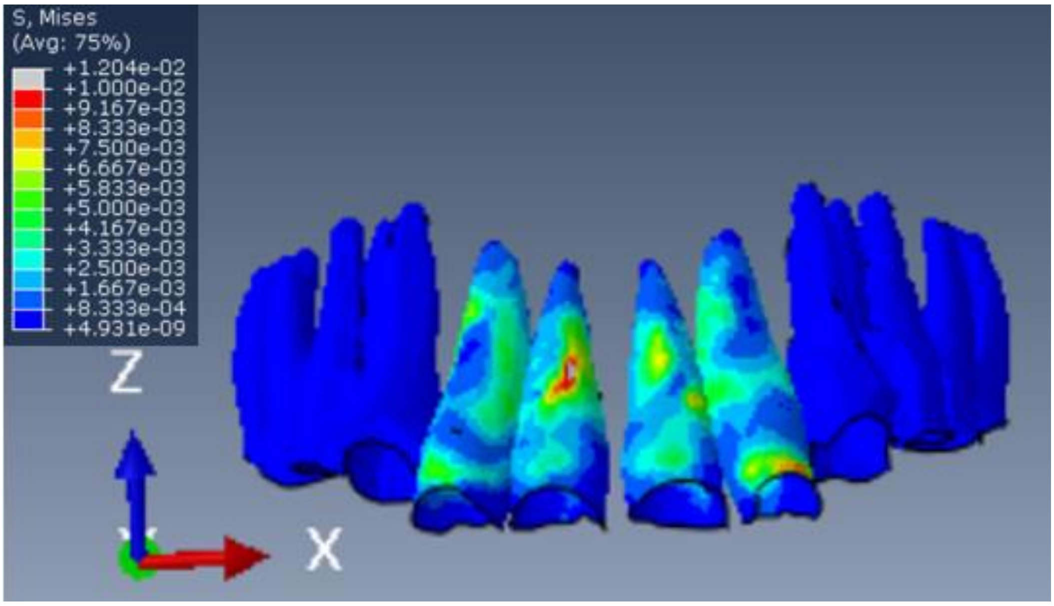


FIGURE 7: GROUP A , TOOTH DISPLACEMENT IN Y-AXIS (SAGITTAL PLANE)

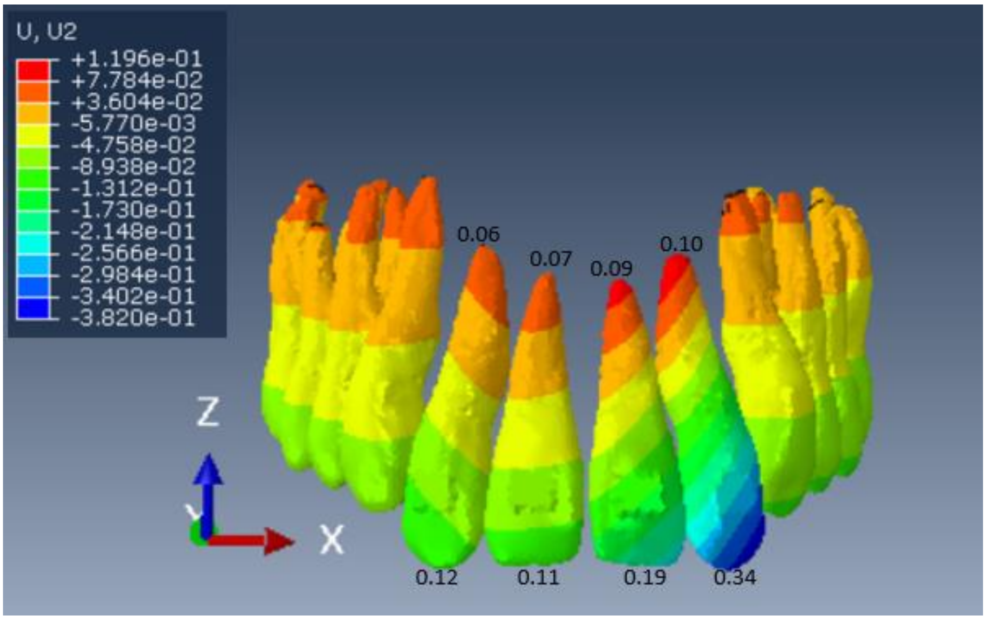


FIGURE 8: GROUP A , TOOTH DISPLACEMENT IN Z-AXIS (VERTICAL PLANE)

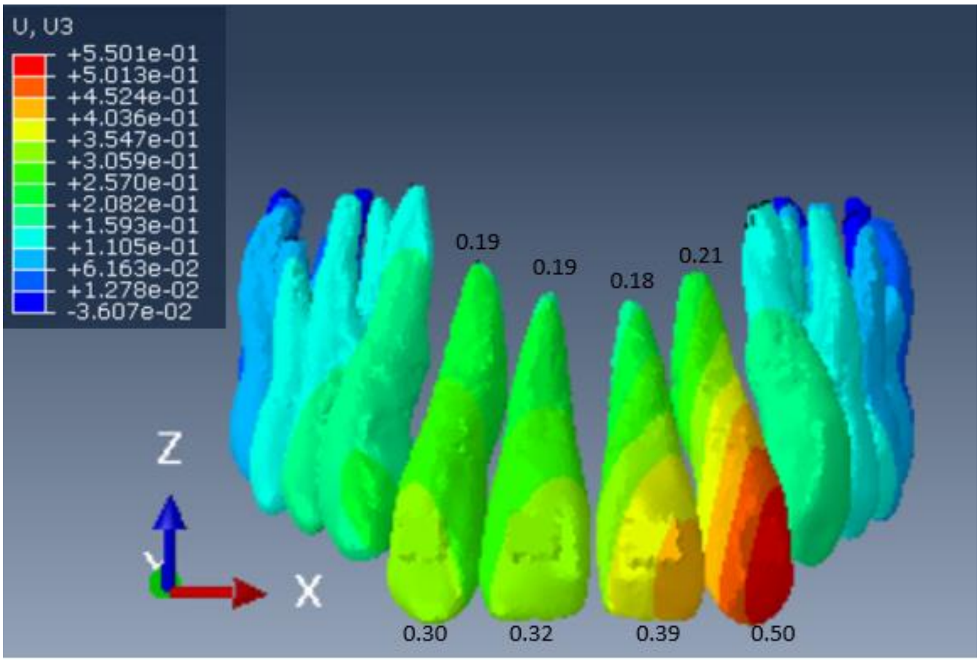


FIGURE 9: GROUP B , TOOTH DISPLACEMENT IN Y-AXIS (SAGITTAL PLANE)

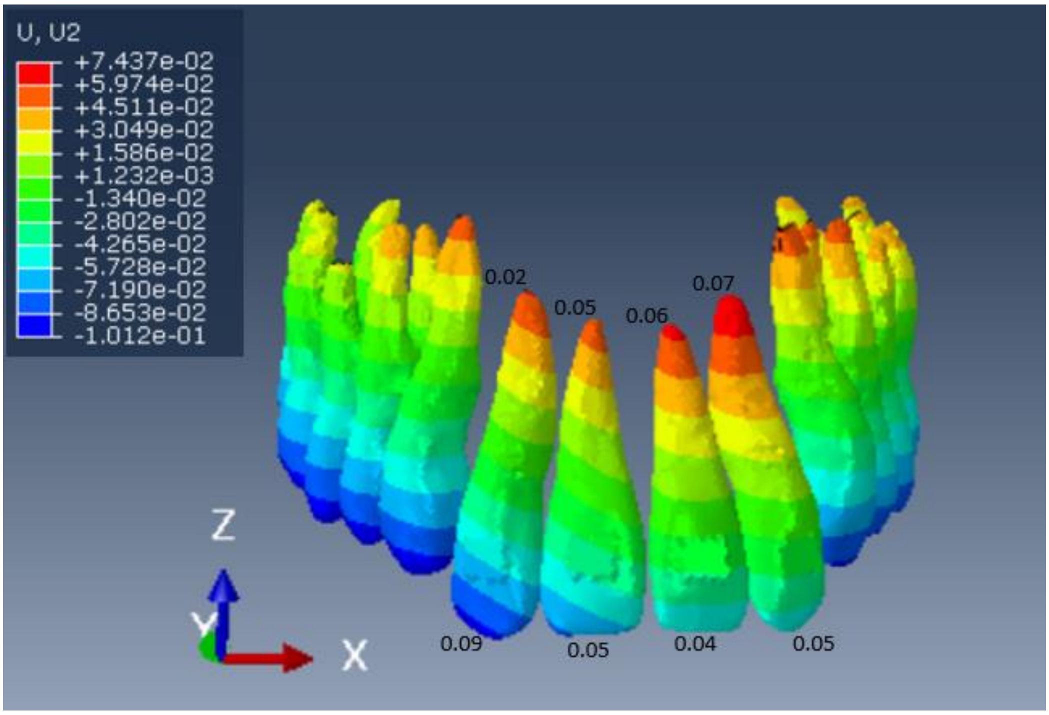
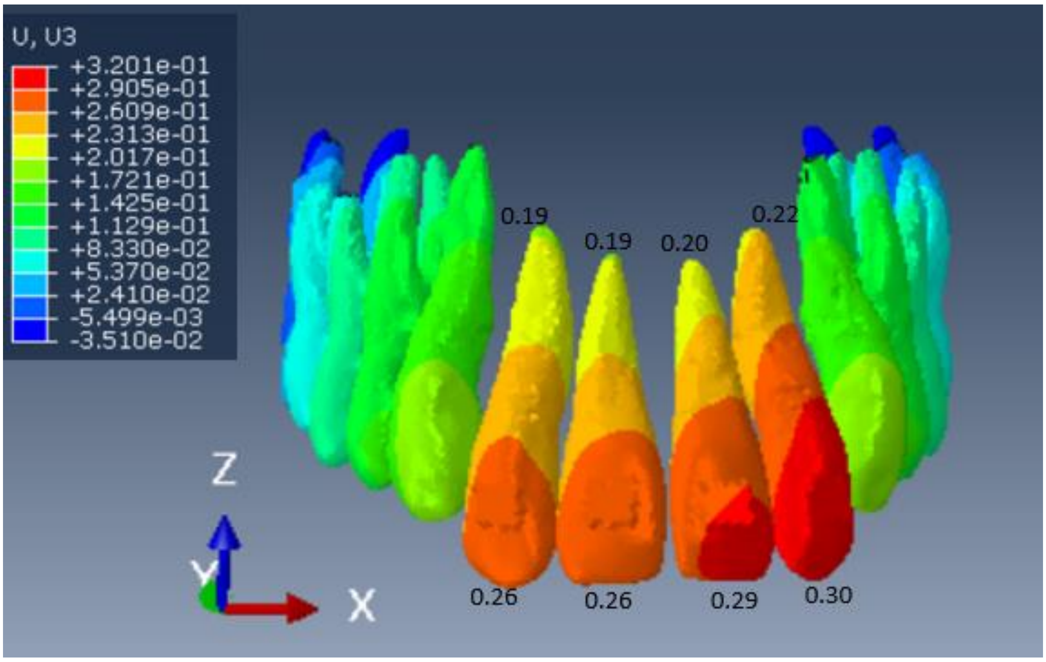


FIGURE 10: GROUP B , TOOTH DISPLACEMENT IN Z-AXIS (VERTICAL PLANE)



Results

RESULTS

The study was conducted to compare the intrusion of four maxillary incisors using three-piece intrusion arch and the temporary anchorage device. The resultant stress and displacement of the dentition was calculated using Finite Element Analysis.

Stress distribution

The value of stress distribution were shown in the spectrum of colours ranging from grey (very high) to blue (lowest) and was obtained in Von mises stress analysis image.

On studying stress pattern in PDL in both the groups, the maximum principal compressive stress was negligible in mini implant groups compared to the three piece intrusion arch. (Figure 5a,5b)(Figure 6a,6b)

The results were discussed under the following headings:

1. Tooth displacement of central and lateral incisors in the X-axis (transverse plane).

2. Tooth displacement of central and lateral incisors in the Y-axis (sagittal plane).

3. Tooth displacement of central and lateral incisors in the Z-axis (vertical plane).

Tooth displacement:

Individual tooth displacement in both the groups was tabulated. The overall displacement of dentition was observed in all three axis X,Y and Z respectively.

Tooth displacement pattern in the X-axis (transverse plane)

The displacement of four maxillary incisors remained relatively constant in the transverse plane in both the groups.

Tooth displacement pattern in the Y-axis (sagittal plane)

The displacement of four maxillary incisors in sagittal direction was observed in both the groups and the results were tabulated. (Figure 7) (Figure 9)

Group A –Three-piece intrusion arch.

Central incisors (#11 and #21)

The central incisors (#11 and #21) showed labial crown tipping in sagittal direction with a minimum and maximum crown tipping of 0.11 mm and 0.19 mm respectively and a mean of 0.15 mm. The minimum root tipping was 0.07 mm while maximum root tipping was 0.09mm with the mean of 0.08 mm.(Table 2)

Lateral incisors (#12 and #22)

The lateral incisors (#12 and #22) showed labial crown tipping in sagittal direction with a minimum and maximum crown tipping of 0.12 mm and 0.34 mm respectively and a mean of 0.23 mm. The minimum root tipping was 0.06 mm while maximum root tipping was 0.10mm with the mean of 0.08 mm. (Table 2)

The descriptive statistics was done to assess crown and root movement in the sagittal plane for all four maxillary incisors in group A, and it showed maximum and minimum crown tipping of 0.340mm and 0.117 mm, with the mean difference 0.192 ±0.103. The maximum root tipping was 0.109 mm and minimum root tipping was 0.069 with the mean difference of 0.085±0.019.(Table 4)

Group B – Mini implant

Central incisors (#11 and #21)

The central incisors (#11 and #21) showed labial crown tipping in sagittal direction with a minimum and maximum crown tipping of 0.05 mm and 0.40 mm respectively and a mean of 0.25 mm. The minimum root tipping was 0.5 mm while maximum root tipping was 0.06mm with the mean of 0.28 mm.(Table 3)

Lateral incisors (#12 and #22)

The lateral incisors (#12 and #22) showed labial crown tipping in sagittal direction with a minimum and maximum crown tipping of 0.09 mm and 0.05 mm respectively and a mean of 0.07 mm. The minimum root tipping was 0.02 mm while maximum root tipping was 0.07mm with the mean of 0.04 mm. (Table 3)

The descriptive statistics was done to assess crown and root movement in the sagittal plane for all four maxillary incisors in group B, and it showed maximum and minimum crown tipping of 0.09mm and 0.04 mm, with the mean difference 0.05 ±0.22. The maximum root tipping was 0.07 mm, and minimum root tipping was 0.02mm with the mean difference of 0.05±0.02.(Table 4)

Tooth displacement pattern on the Z-axis (vertical plane)

The displacement of four maxillary incisors in vertical direction was observed in both the groups and the results are tabulated.(Figure 8) (Figure10)

Group A- Three piece intrusion arch

Central incisors (#11 and #21)

The central incisors (#11 and #21) intruded with a minimum and maximum crown intrusion of 0.32 mm and 0.39 mm respectively and a mean of 0.35 mm. The minimum root intrusion was 0.19 mm while maximum root intrusion was 0.18mm with the mean of 0.18mm. (Table 2)

Lateral incisors (#12 and #22)

The lateral incisors (#12 and #22) intruded with a minimum and maximum crown intrusion of 0.30 mm and 0.50 mm respectively and a mean of 0.40 mm. The minimum root intrusion was 0.19 mm while maximum root intrusion was 0.21mm with the mean of 0.2 mm. (Table 2)

The descriptive statistics was done to assess crown and root movement in the vertical plane for all four maxillary incisors in group A, and it showed maximum and minimum crown intrusion of 0.50 mm and 0.30 mm, with the mean difference 0.38 ±0.09. The maximum root intrusion was 0.21 mm and minimum root intrusion was 0.18mm with the mean difference of 0.19±0.013. (Table 4)

Group B- Mini implant

Central incisors (#11 and #21)

The central incisors (#11 and #21) intruded with a minimum and maximum crown intrusion of 0.26 mm and 0.29 mm respectively and a mean of 0.27 mm. The minimum root intrusion was 0.19 mm while maximum root intrusion was 0.20mm with the mean of 0.19mm. (Table 3)

Lateral incisors (#12 and #22)

The lateral incisors (#12 and #22) intruded with a minimum and maximum crown intrusion of 0.26 mm and 0.30 mm respectively and a mean of 0.28 mm. The minimum root intrusion was 0.19 mm while maximum root intrusion was 0.22mm with the mean of 0.20 mm. (Table 3)

The descriptive statistics was done to assess crown and root movement in the vertical plane for all four maxillary incisors in group B, and it showed maximum and minimum crown intrusion of 0.30 mm and 0.26 mm, with the mean difference 0.28 ±0.20. The maximum root intrusion was 0.22 mm and minimum root intrusion was 0.19mm with the mean difference of 0.20±0.01. (Table 4)

Tables and Graphs

TABLE 2: DISPLACEMENT OF TEETH IN ALL THREE AXIS USING THREE PIECE INTRUSION ARCH (GROUP A)

TOOTH	AXIS	DISPLACEMENT IN CROWN (mm)	DISPLACEMENT IN ROOT (mm)
CENTRAL INCISOR (11)	X	0.012	0.013
	Y	0.117	0.070
	Z	0.323	0.199
CENTRAL INCISOR (21)	X	0.087	0.049
	Y	0.192	0.092
	Z	0.396	0.181
LATERAL INCISOR (12)	X	0.058	0.012
	Y	0.122	0.069
	Z	0.306	0.198
LATERAL INCISOR (22)	X	0.223	0.075
	Y	0.340	0.109
	Z	0.505	0.213

TABLE 3: DISPLACEMENT OF TEETH IN ALL THREE AXIS USING TEMPORARY ANCHORAGE DEVICE (GROUP B)

TOOTH	AXIS	DISPLACEMENT IN CROWN (mm)	DISPLACEMENT IN ROOT (mm)
CENTRAL INCISOR (11)	X	0.037	0.001
	Y	0.056	0.550
	Z	0.268	0.195
CENTRAL INCISOR (21)	X	0.055	0.009
	Y	0.040	0.063
	Z	0.293	0.205
LATERAL INCISOR (12)	X	0.014	0.018
	Y	0.092	0.022
	Z	0.264	0.193
LATERAL INCISOR (22)	X	0.073	0.041
	Y	0.054	0.071
	Z	0.307	0.222

TABLE 4: GROUPWISE MEAN AND STANDARD DEVIATION FOR ALL SIX VARIABLES

GROUP A:

Descriptive Statistics

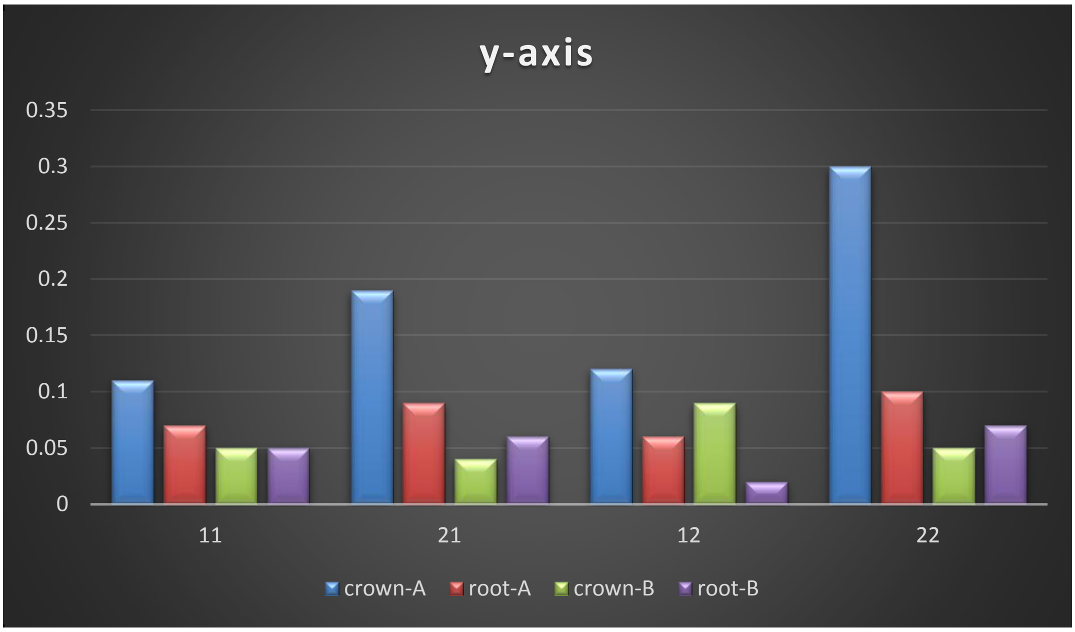
	N	Minimum	Maximum	Mean	Std. Deviation
CROWN X	4	.012	.223	.09500	.090749
CROWN Y	4	.117	.340	.19275	.103966
CROWN Z	4	.306	.505	.38250	.090519
ROOT X	4	.0100	.0700	.035500	.0290345
ROOT Y	4	.069	.109	.08500	.019201
ROOT Z	4	.181	.213	.19775	.013099
Valid N (listwise)	4				

GROUP B:

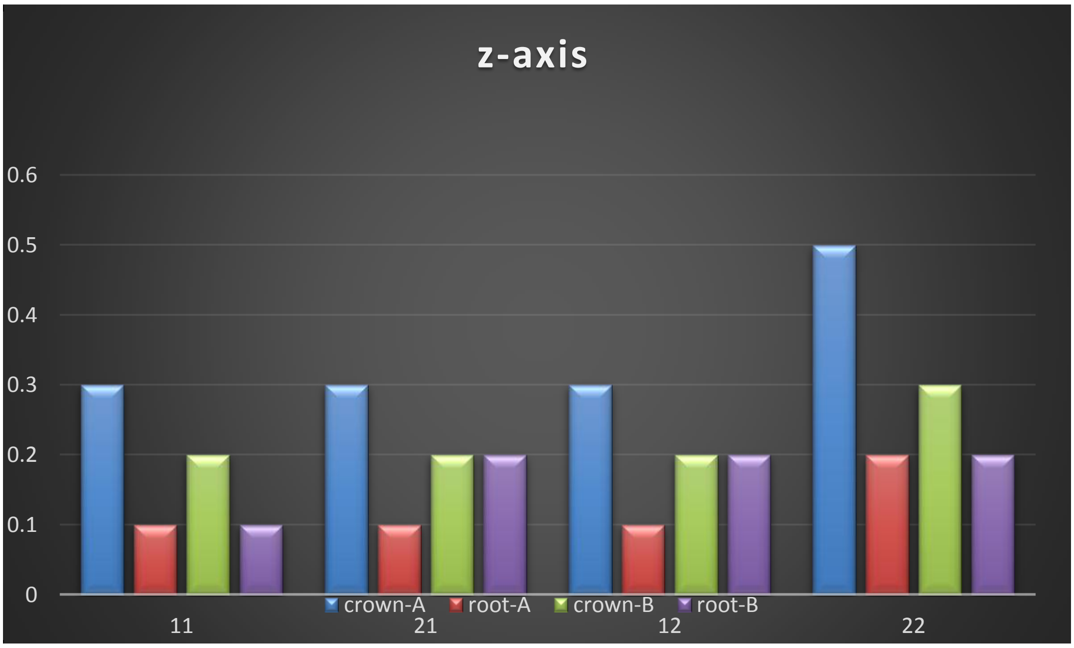
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CROWN X	4	.014	.073	.04475	.025224
CROWN Y	4	.040	.092	.05900	.022774
CROWN Z	4	.264	.307	.28300	.020510
ROOT X	4	.0010	.0410	.017250	.0172892
ROOT Y	4	.022	.071	.05275	.021515
ROOT Z	4	.193	.222	.20375	.013251
Valid N (listwise)	4				

GRAPH 1: MEAN DIFFERENCE OF CROWN AND ROOT MOVEMENT IN BOTH THE GROUPS(SAGITTAL PLANE)



GRAPH 2: MEAN DIFFERENCE OF CROWN AND ROOT MOVEMENT IN BOTH THE GROUPS(VERTICAL PLANE)



Discussion

DISCUSSION

Vertical discrepancies are one of the most challenging aspects of orthodontic treatment. The vertical disparities manifests either as deep bite or open bite and can involve skeletal and/or dentoalveolar component[37].Deep bite is the one of the commonest malocclusion seen in children as well as in adults. The prevalence of deep bite ranges from 11.8% to 36.7% and approximately 70% of patients had mild to moderate degree of deep bite which occurred along with other associated malocclusions. In all categories of deep bite, female to male ratio was higher.[60]

Deepbite is a condition that warrants early intervention since it poses deleterious long term effects on masticatory apparatus and the dental unit, if left untreated. Some of the unfavorable sequelae of this malocclusion are periodontal breakdown, abnormal functions, and habits like bruxism, clenching and temporomandibular dysfunctions.[36]

Deepbite can either be skeletal, dental or both. Etiology of deep bite can be due to inherent or acquired factors: 1) Inherent factors like tooth morphology, growth pattern and type of malocclusion. 2) Acquired factors are habits like tongue thrust and aberrant functions like bruxism etc.[26]

Deepbite can also occur due to decreased lower anterior face height, lack of eruption of posterior teeth or over eruption of the anterior teeth. Therefore, it is essential to identify the etiology prior to formulating a treatment plan. Taking certain esthetic parameters into concern such as the position of the maxillary incisor with the upper lip plays a key role in determining deepbite correction. According to **Proffit** gingival display of 4mm is acceptable beyond which smile appearance appears less attractive.[62]

In patients with extruded maxillary incisors and increased maxillary incisor exposure at rest, deepbite is corrected by intruding the incisors by absolute intrusion. However, the absolute intrusion if not biomechanically controlled with proper force systems can predispose to root resorption.

Dellinger is probably the first to demonstrate intrusion histologically and cephalometrically on premolars of monkeys. He applied a controlled force of 50 grams and attained 2.9 millimetres of intrusion, with very little resorption, and some compression at the apical region. Along the root surface, the periodontal ligament was in a state of tension and thickened, while new trabeculae were being formed.

Loop mechanics with determinant force system is one of the proven methods for intruding the anterior segment. There are various designs of intrusion arches reported and studied in the literature.[8]

One of the major challenges of orthodontic treatment is the correction of deepbite and there is a sufficient literature evidence to show that conventional segmental intrusion arches are the preferred method. Some of the conventional methods of incisors intrusion include segmental arches, utility arches, three-piece intrusion arches or reversed curved arches.[8,62,56]

In the present study, three piece intrusion arch introduced by **Shroff** in 1995 was used that provides light continuous force and it is well validated in literature. However, these conventional method causes labial tipping of the anterior teeth which may or may not be desirable in all the patients.[63]

Temporary anchorage device has been a big boon to the orthodontists and clinicians and there are few clinical studies that advocates the use of mini implants for true incisor intrusion of anterior teeth without undue flaring of the maxillary incisors.

The advent of mini implant in orthodontics have expanded the envelope of discrepancy thus enabling complex tooth movement possible. It is well established in literature that incisor intrusion can be done using mini-implants with minimal flaring of the anterior teeth. [37]

There are studies done previously comparing the efficiency of the intrusion with conventional methods and mini implants. **Neslihan** et al[62] compared the treatment effects of Connecticut intrusion arches and mini implant in deep bite patients and concluded that both the methods successfully intruded the four maxillary incisors. However, the movement of maxillary incisors led to anchorage loss in both the sagittal and vertical dimension in the Connecticut intrusion arch group, while these anchorage were maintained in the implant group. Similar results were obtained by **Omar Polat** et al who compared utility arch and mini implant for intrusion of incisors.[55]

Previous literature that has compared conventional intrusion method and mini implants shows that mini implant produce promising results in the form of true incisor intrusion and minimal flaring of anterior teeth.[8,53,34,10]

Intrusion of the anterior teeth is usually restricted to four incisors with conventional methods. However, the advent of mini implants facilitate and permit simultaneous intrusion of all six anterior teeth without any adverse effects.

In the present study as we are comparing a conventional method and mini implant group, we restricted the intrusion model to only four maxillary incisors.

The position and number of mini implants for anterior intrusion has been studied previously and is topic of debate if a single mini-implant is sufficient or two mini-implants are preferred for intrusion of maxillary anterior teeth.[67,68] It is believed that from biomechanical stand point, a force that passes through centre of resistance would produce true intrusion with minimal flaring of the incisors . The center of resistance of the four incisors lies 8–10 mm apically and 5–7 mm distal of the lateral incisors. By placing the implants distal to the maxillary lateral incisors, the intrusive force could be applied close to the center of resistance of the four incisors, and there would be no or minimal flaring.[30,59]

Finite Element Analysis (FEA) is a numerical method of engineering that has been successfully used to model the force systems to the teeth and to study the orthodontic teeth displacement and stress magnitudes.[59]

One of the most detrimental side effects of orthodontic tooth movement particularly with intrusion is root resorption, when the intrusive forces produce greater stress at the apical region of the tooth.[59]

Saga et al[59] studied the stress distribution with different part of force application in a FEM model of maxillary incisors.The point of force application selected and were centered between the central incisor bracket; bilateral between the central and lateral brackets; bilateral distal to lateral incisor bracket; 7mm distal to the lateral incisor brackets bilaterally and the results showed that stress concentration was predominantly at the periodontal ligament root apex irrespective of the point of force application.

To the best of our knowledge, then has been no study that has compared the efficiency of intrusion with three-piece intrusion arch and mini implant.

Thus the present study was done to validate the biomechanical response of three-piece intrusion arch and mini implant assisted intrusion of maxillary four incisors using finite element method. The stress distribution and the overall displacement of dentition was calculated.

In our study, A model was created with maxillary four incisors at a lower level than the posterior occlusal plane simulating anterior deepbite. The inclination of the maxillary incisors were kept normal.The intrusion was simulated using three-piece intrusion arch with a force of 140 grams (70 grams per each side) in the group A.

In the present study, a 17x25 TMA was used in the three-piece intrusion arch. In a study by **Iosif Sifakakis et al**[64] he showed that the intrusion arch fabricated using 17x25 TMA alloy exihibited the lowest intrusive force compared to 0.016x 0.0.16 Blue Elgiloy. Moreover, **Bhavna Shroff**[63]recommended the use of 17x25 TMA due to the low load deflection rate and constancy of the force

In group B, two mini implants were placed one on either side between the lateral incisors and canines and intrusion was simulated by tying the ligature wire from the implants to the base arch wire. It is however debated if a single mini implant placed in the centre of the alveolus between two central incisors is sufficient or two mini implants are necessary for intrusion of maxillary anterior teeth. However, a single mini implant causes undue flaring or proclination of maxillary incisors. This is reported in the literature by **Kim et al**[36] that, with single implant, the forces passes anterior to the centre of resistance of maxillary incisors thereby resulting in unwanted proclination of the incisors.

The result of the present study shows that the compressive stresses were less in the implant group compared to the three piece intrusion arch. Perhaps, the stresses in the apical areas of the maxillary four incisors was significantly lesser in both the groups compared to the cervical third of crown region. This is in contradicting to the study by **Saga et al**[59] who showed the stress concentration predominantly in the apical region irrespective of force application. However, a study by **Sagar Padmawan et al**[53] concluded that the stress was distributed more evenly when the point of the application is bilateral rather than a single source.

This could be attributed to the fact that the FEM analysis shows the stress generated at the initial time of force application and not over a period of time. Similar results have been obtained previously.[53]

The displacement of the maxillary four incisors were calculated for both the groups. The overall displacement was observed in all three planes of space. In the transverse plane, the displacement of the anterior teeth was fairly constant in both the groups.

In the sagittal plane, there was greater tipping of maxillary incisors with intrusion arch compared to the implants. This is due to the difference in the point of force application and direction of force passing higher and closer to the center of resistance of maxillary incisors with implant assisted intrusion compared to the three-piece intrusion. This is well supported in literature.[67]

The vertical intrusion of the maxillary incisors was calculated in both the groups. Three-piece intrusion arch depicted more amount of intrusion in terms of crown movement compared to the implant assisted intrusion. However, the root intrusion was fairly the same in both the groups. Literature studies[62] have used either the incisor crown tip or the apex for assessing the quantum of intrusion on radiographs. However, labial tipping of incisors gives the clinical impression of deep bite correction as it influences the vertical incisal edge position.

Thus, in the present study, although the vertical intrusion was greater in the three- piece intrusion arch group, it also showed greater flaring of maxillary incisors, thus depicting relative intrusion.

In the implant group, there was true incisor intrusion without any undue flaring of the maxillary incisors. This was achieved by passing the intrusive force through the centre of resistance of four maxillary incisors.

Omar Polat et al[55] compared the effect of mini implant and utility arches for incisor intrusion and concluded that mini implant have simplified most of the orthodontic mechanics and was effective in producing true intrusion with minimal incisor protrusion. Similar results have been obtained by **Neslihan et al**[62] who compared Connecticut intrusion arch with mini implant assisted intrusion.

Among all orthodontic tooth movement, intrusion is probably the most detrimental in orthodontics. These forces generates stress that can cause changes on the tooth structure and periodontal ligament.[14]

Over the years, FEM has been successfully used to generate the stress distribution and it is believed that stresses on the teeth are less and distributed more evenly, when the point of force application is bilateral thus warranting the use of two mini implants one on either side distal of lateral incisors for effective intrusion.[14,53,59]

CLINICAL IMPLICATION:

Three-piece intrusion arch and mini-implant assisted intrusion were effective in intruding the maxillary incisors. However, mini-implants were effective in producing true incisor intrusion with minimal flaring of the anterior tooth. In patients with proclined incisors like Class II div I malocclusion it may be prudent to achieve true incisor intrusion without proclining the maxillary incisor. While, in Class II div 2 malocclusion with retroclined maxillary incisors, some amount of labial flaring of the incisors is permissible and may be warranted.

LIMITATION OF THE PRESENT STUDY:

This is an in-vitro study and the outcome cannot be directly extrapolated to clinical conditions. The inclination of the maxillary incisors at the start of treatment is another important key factor to measure, that can affect the point and direction of force and the intrusion attained. This was not incorporated in the present study.

FUTURE:

Controlled clinical trials with matched samples are needed to validate the efficiency of implant assisted intrusion.

Summary & Conclusion

SUMMARY AND CONCLUSION

The present FEM study was carried out to compare the stress distribution and displacement of four maxillary incisors using three-piece intrusion arch and mini-implant assisted intrusion.

A three-piece intrusion arch with intrusion spring made of 17x25 TMA was used. Two mini implants, 1.3x7mm diameter was placed one on each side distal to the lateral incisors and a force of 140 grams (70 grams per side) was given in both the groups.

The following conclusions can be drawn from the present study:

1. The maximum principal compressive stress was negligible in mini implant groups compared to the three-piece intrusion arch.
2. Displacement of maxillary incisors was fairly constant in both the groups in the transverse dimension.
3. Displacement of four incisors were significantly different for both the groups in sagittal and vertical plane.
4. In the sagittal plane, three- piece intrusion arch showed greater labial tipping of maxillary incisors compared to the mini implant assisted intrusion.
5. In vertical plane, there was a more of bodily intrusion of maxillary incisors in the implant group compared to the conventional group.

Bibliography

1. **Ahuja S, Gupta S, Bhambri E, Ahuja V, Jaura BS.** Comparison of conventional methods of simultaneous intrusion and retraction of maxillary anterior: a finite element analysis. J Orthod. 2018 2;45(4):243-9.
2. **Akin-Nergiza N, Nergizb I, Schulzb A, Arpakc N, Niedermeierd W**. Reactions of peri-implant tissues to continuous loading of osseointegrated implants. Am J Orthod Dentofac.Orthop.1998; 114:292-8
3. **Al-Buraiki H, Sadowsky C, Schneider B**. The effectiveness and long-term stability of overbite correction with incisor intrusion mechanics. Am J Orthod Dentofac.Orthop.2005;127:47–55
4. **Amarnath BC**. Clinical overview of deep bite management. IJOCD.2010 1; 1(2).
5. **Amasyali M, Sağdiç D, Ölmez H, Akin E, Karaçay Ş**. Intrusive effects of the connecticut intrusion arch and the utility intrusion arch. Turk J Med Sci. 2005 23; 35:407-15.
6. **Baldwin JJ**. Consideration of Forces for Tooth Movement. World J Orthod. 2003 1; 4(3).
7. **Becker W, Sennerby L, Becker BE, Henry P**. Clinical and histologic findings for microimplants placed in one stage and loaded for three months: a case report. Clin Implant Dent Relat Res. 2002; 4(1):47-52.
8. **Belludi A, Bhardwaj A, Gupta A, Karandikar A**. Orthodontic intrusion &58; Conventional and mini-implant assisted intrusion mechanics. APOS Trends in Orthodontics. 2012 1; 2(4):2-.

9. **Berg R**. Stability of deep overbite correction. Eur J Ortho. 1983 1; 5(1):75-83.

10. **Bhat M, Ninan VS, Somaiah S, Madhur V**. Evaluation of apical root resorption in orthodontic patients with maxillary anterior intrusion using utility arches and mini screws: A comparative clinical trial. APOS Trends in Orthodontics. 2014 1; 4(1):3.

11. **Birtemelson** , overview guideline for success in placement of orthodontic mini implants. J Clin Orthod 2009:01:39-44.

12. **Block MS, Hoffman DR**. A new device for absolute anchorage for orthodontics. Am J Orthod Dentofac Orthop 1995; 107:251-8.https://sci-hub.tw/10.1016/s0889-5406(95)70140-0

13. **Block MS, Hoffman DR**. A new device for absolute anchorage for orthodontics. Am J Orthod Dentofac Orthop 1995; 107:251-8.

14. **Bohara P, Kumar M, Sharma H, Jayprakash PK, Misra V, Savana K**. Stress distribution and displacement of maxillary anterior teeth during en-masse intrusion and retraction: A FEM study. J Indian Orthod Soc. 2017 1;51(3):152.

15. **Braun S, Marcotte MR**. Rationale of the segmented approach to orthodontic treatment. Am J Orthod Dentofac Orthop 1995; 108:1-8.

16. **Bulcke MM, Dermaut LR, Sachdeva RC, Burstone CJ**. The center of resistance of anterior teeth during intrusion using the laser reflection technique and holographic interferometry. Am J Orthod Dentofac Orthop 90: 21 l-220, 1986.

17. **Burstone CJ**. Deep overbite correction by intrusion. Am J Orthod Dentofac Orthop 1977 1;72(1):1-22.

18. **Cattaneo PM, Dalstra M, Melsen B.** The finite element method: a tool to study orthodontic tooth movement. J Dent Res. 2005; 84(5):428-33.

19. **Chandrasekharan D, Balaji SM**. Intrusion of anterior teeth to improve smile esthetics. J Oral-Maxillofac Surg. 2010 1; 9(1):27-9.

20. **Charles R. Burstone** deep overbite correction by intrusion. Am J Orthod Dentofac Orthop. 1977 1; 72(1):1-22.

21. **Chen YJ, Yao CC, Chang HF.** Nonsurgical correction of skeletal deep overbite and class II division 2 malocclusion in an adult patient. Am J Orthod Dentofac Orthop. 2004;126:371-8

22. **Cope JB**. Temporary anchorage devices in orthodontics: a paradigm shift. Semin Orthod 2005 Vol. 11, No. 1, pp. 3-9.

23. **Costa A, Pasta G, Bergamaschi G**. Intraoral hard and soft tissue depths for temporary anchorage devices. Semin Orthod 2005 Vol. 11, No. 1, pp. 10-15.

24. **Costopoulos G, Nanda R**. An evaluation of root resorption incident to orthodontic intrusion. Am J Orthod Dentofac Orthop 1996; 109:543-8.

25. **Creekmore TD**. The possibility of skeletal anchorage. J Clin Orthod. 1983; 17:266-9.

26. **Daokar S, Agrawal G**. Deep Bite Its Etiology, Diagnosis and Management: A Review. J Orthod Endod. 2016.

27. **De Clerck HJ, Timmerman HM, Cornelis MA**. Biomechanics OF Skeletal Anchorage. Part 3. Intrusion. J CLIN ORTHOD. 2008; 42:270-8.

28. **Deguchi T, Murakami T, Kuroda S, Yabuuchi T, Kamioka H, Takano-Yamamoto T**. Comparison of the intrusion effects on the maxillary incisors between implant anchorage and J-hook headgear. Am J Orthod Dentofac Orthop 2008;133:654-60
29. **Del Castillo McGrath MG, Araujo-Monsalvo VM, Murayama N, Martínez-Cruz M, Justus-Doczi R, Domínguez-Hernández VM, Ondarza-Rovira R.** Mandibular anterior intrusion using miniscrews for skeletal anchorage: A 3-dimensional finite element analysis. Am J Orthod Dentofac Orthop 2018;154:469-76
30. **Gupta RK, Tikku T, Khanna R, Verma SL, Srivastava K**. Effect of Intrusive Forces on Maxillary Central Incisor at Different Inclinations at Normal Bone Height–A FEM Study. IJIEASR.2016;5:7
31. **Hoste S, Vercruyssen M, Quirynen M, Willems G**. Risk factors and indications of orthodontic temporary anchorage devices: a literature review. Aust J Orthod. 2008 1; 24(2):140-8.
32. **Ioanis**. Center of resistance in orthodontics. Helenic orthodontic review. 2005:vol:8;pgs:44-57.
33. **Ivanoff CJ, Widmark G, Hallgren C, Sennerby L, Wennerberg A**. Histologic evaluation of the bone integration of TiO2 blasted and turned titanium microimplants in humans. Clinical Oral Implants Research. 2001; 12(2):128-34.
34. **Jain RK, Kumar SP, Manjula WS**. Comparison of intrusion effects on maxillary incisors among mini implant anchorage, j-hook headgear and utility arch. J Orthodont Res 2014; 8(7):ZC21.

35. **Kanomi R.** Mini-implant for orthodontic anchorage. J. clin. Orthod... 1997; 31:763-7.

36. **Kim TW, Kim H, Lee SJ.** Correction of deep overbite and gummy smile by using a mini-implant with a segmented wire in a growing Class II Division 2 patient. Am J Orthod Dentofac Orthop 2006;130:676-85

37. **Krishnaswamy NR**. Vertical control with TADs: Procedures and protocols. Semin Orthod 2018 Vol. 24, No. 1, pp. 108-122.

38. **Kuroda S, Sugawara Y, Deguchi T, Kyung HM, Takano-Yamamoto T.** Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. Am J Orthod Dentofac Orthop 2007; 131:9-15

39. **Kyung HM.** Overview development of orthodontic micro-implants for intraoral anchorage. J. clin. Orthod.. 2003; 37:321-8.

40. **Leonard I. Linkow,** Implanto-orthodontics, J Clin orthod 1970;4(12):685-705

41. **Levin RI**. Deep bite treatment in relation to mandibular growth rotation. Eur. J. Orthod 13 (1991) 86-94

42. **Lindauer SJ, Lewis SM, Shroff B.** Overbite correction and smile aesthetics. Semin Orthod 2005 Vol. 11, No. 2, pp. 62-66.

43. **Liou EJ, Pai BC, Lin JC**. Do miniscrews remain stationary under orthodontic forces? Am J Orthod Dentofacial Orthop 2004;126:42-7

44. **Marusamy KO, Ramasamy S, Akondi BR, Cherackal GJ, Arabia S**. True orthodontic intrusion using three-piece intrusion arch for correcting excessive gingival exposure. Surgical Techniques Development. 2018 26; 8(1):7762.

45. **Melsen B, Agerbaek N, Markenstam G.** Intrusion of incisors in adult patients with marginal bone loss. Am J Orthod Dentofacial Orthop 2004;126:42-7

46. **Melsen B.** Biological reaction of alveolar bone to orthodontic tooth movement. Angle Orthod. 1999; 69(2):151-8.

47. **Melsen B**. Tissue reaction following application of extrusive and intrusive forces to teeth in adult monkeys. Am J Orthod Dentofacial Orthop 89: 469-475, 1986.

48. **Mittal R, Patil AK, Ganeshkar SV.** Correction of deep overbite with mini-implants in adult patients. Orthod Cyber J. 2009; 1:1-2.

49. **Morea C, Dominguez GC, Wuo AV, Tortamano A**. Surgical guide for optimal positioning of mini-implants. J Clin Orthod. 2005 ;39(5):317-21.

50. **Nayak UK, Kuttappa MN, Shetty A, Godhrawala F**. Evaluation of True Incisor Intrusion Attained with Mini-Implant Anchorage System for the Correction of Deep Overbite. J Indian Orthod Soc.2010 1; 44(2):18-24.

51. **Ng J, Major PW, Heo G, Flores-Mir C**. True incisor intrusion attained during orthodontic treatment: a systematic review and meta-analysis. . Am J Orthod Dentofacial Orthop 2005;128: 212-9

52. **Ohmae M, Saito S, Morohashi T, Seki K, Qu H, Kanomi R, Yamasaki KI, Okano T, Yamada S, Shibasaki Y**. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. Am J Orthod Dentofacial Orthop 2001;119:489-97

53. **Padmawar SS, Belludi A, Makhija PG, Bhardwaj A, Virang B**. Stress appraisal with simulation of en masse absolute intrusion of maxillary anteriors

deploying strategic mini-implant locations: a finite element analysis. J Indian Orthod Soc. 2012 1; 46(2):77-81.

54. **Parker CD, Nanda RS, Currier GF**. Skeletal and dental changes associated with the treatment of deep bite malocclusion. Am j orthod dentofac orthop 1995; 107:382-93.

55. **Polat-Özsoy Ö, Arman-Özçırpıcı A, Veziroğlu F, Çetinşahin A.** Comparison of the intrusive effects of miniscrews and utility arches. Am J Orthod Dentofacial Orthop 2011;139:526-32

56. **Polat-Ozsoy O, Arman-Ozcirpici A, Veziroglu F**. Miniscrews for upper incisor intrusion. Eur J Orthod 31 (2009) 412–416

57. **Pryputniewicz RJ, Burstone CJ**. The effect of time and force magnitude on orthodontic tooth movement. J. Dental Res 1979 58(8):1754-64.

58. **Radney LJ, Jacobs JD.** Soft-tissue changes associated with surgical total maxillary intrusion. Am J Orthod Dentofacial Orthop 1981 1;80(2):191-212.

59. **Saga AY, Maruo H, Argenta MA, Maruo IT, Tanaka OM**. Orthodontic intrusion of maxillary incisors: a 3D finite element method study. Dental press J orthod. 2016 21(1):75-82.

60. **Saqib naeeem,saadasad,mwaheed-ul-hamid,** prevelance of deep bite in orthodontic patients. Pakistan Oral & Dental journal vol28, no. 2.

61. **Schütz-Fransson U, Bjerklin K, Lindsten R**. Long-term follow-up of orthodontically treated deep bite patients. Eur J Orthod 28 (2006) 503–512

62. **Şenışık NE, Türkkahraman H.** Treatment effects of intrusion arches and mini-implant systems in deepbite patients. Am J Orthod Dentofacial Orthop 2012;141:723-33

63. **Shroff B, Yoon WM, Lindauer SJ, Burstone CJ**. Simultaneous intrusion and retraction using a three-piece base arch. Angle Orthod 1997; 67(6):455-462.
64. **Sifakakis I, Pandis N, Makou M, Eliades T, Bourauel C.** Forces and moments generated with various incisor intrusion systems on maxillary and mandibular anterior teeth. Angle Orthod. 2009; 79(5):928-933.
65. **Simons ME, Joondeph DR.** Change in overbite: a ten-year postretention study. Am J Orthod 1973 1;64(4):349-67.
66. **Sunita sahu,shuvesasamantaray, nivedithasahoo, Pritam Mohanty, snigdhagowd, baratam Srinivas**, orthodontic intrusion:an insight, Int j oral health med res 2017;3(6):137-140.
67. **Tilekar NR, Swami V, Sabane A, Bhosale V**. Comparison of the effects of varying positions of mini-implants on intrusion of maxillary incisors-an In vivo study. J Indian Orthod Soc. 2018 1; 52(1):35.
68. **Tilekar NR, Swami V, Sabane A, Bhosale V.** Comparison of the effects of varying positions of mini-implants on intrusion of maxillary incisors-an In vivo study. J Indian Orthod Soc. 2018 1; 52(1):35.
69. **Upadhyay M, Nagaraj K, Yadav S, Saxena R**. Mini-implants for en masse intrusion of maxillary anterior teeth in a severe Class II division 2 malocclusion. J orthod. 2008 1; 35(2):79-89.
70. **Van den Bulcke and L. R. Dermaut**.The interaction between reaction forces and stabilization systems during intrusion of the anterior teeth and its effect on the posterior unit .Eur J Orthod (1990) 12(4): 361-369.

71. **Van Steenbergen E, Burstone CJ, Prahl-Andersen B, Aartman IH**. The influence of force magnitude on intrusion of the maxillary segment. Angle Orthod 2005; 75:723–729.

72. **Varlık SK, Alpakan ÖO, Türköz Ç**.Deepbite correction with incisor intrusion in adults: a long-term cephalometric study. Am J Orthod Dentofacial Orthop 2013;144:414-9

73. **W. Michael Mcfadden ,DMD,MS, christerengstrom, dds** , a study of relationship between root shortening and incisor intrusion. Am J Orthod Dentofac Orthop 1989; 96:390-6.

74. **Yoshida N, Jost-Brinkmann PG, Koga Y, Mimaki N, Kobayashi K**. Experimental evaluation of initial tooth displacement, center of resistance, and center of rotation under the influence of an orthodontic force. Am J Orthod Dentofacial Orthop 2001;120:190-7

75. **Yoshida;y.koga.**In vivo determination of of center of resistance of upper anterior subjected to retraction forces. Eur J Orthod 2001, vol-23pgs-529-53.

76. **Young KA, Melrose CA, Harrison JE**. Skeletal anchorage systems in orthodontics: absolute anchorage. A dream or reality? J Orthod. 2007 1; 34(2):101-10.

Annexures

ANNEXURE –1

RAGAS DENTAL COLLEGE & HOSPITAL

(Unit of Ragas Educational Society)
Recognized by the Dental Council of India, New Delhi
Affiliated to The Tamilnadu Dr. M.G.R. Medical University, Chennai
2/102, East Coast Road, Uthandi, Chennai - 600 119. INDIA
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TO WHOM SO EVER IT MAY CONCERN

Date: 18-01-19

Chennai.

From,

The Institutional Review Board,

Ragas Dental College and Hospital,

Uthandi, Chennai-600119.

The Dissertation topic titled **"COMPARISON OF INTRUSION IN MAXILLARY INCISORS USING THREE PIECE INTRUSION ARCH AND SKELETAL ANCHORAGE –A FINITE ELEMENT STUDY"** submitted by **Dr.Kowtham Raj.M** has been approved by the Institutional Review Board of Ragas Dental College & Hospital.

Dr. N S Azhagarasan, M.D.S
Member Secretary,
Institutional Ethical Board,
Ragas Dental College and Hospital,
Uthandi, Chennai-600119.

ANNEXURE – II

URKUND

Urkund Analysis Result

Analysed Document: full thesis.docx (D47615550)
Submitted: 2/5/2019 1:58:00 PM
Submitted By: kowthamdent@gmail.com
Significance: 5 %

Sources included in the report:

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http://www.jios.in/article.asp?issn=0301-5742;year=2018;volume=52;issue=1;spage=35;epage=43;aulast=Tilekar

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